The American Journal of Surgery

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TRAUMATIC SURGERY

Papers Read at the June 1948 Meeting of The American Association for the Surgery of Trauma

November 1948

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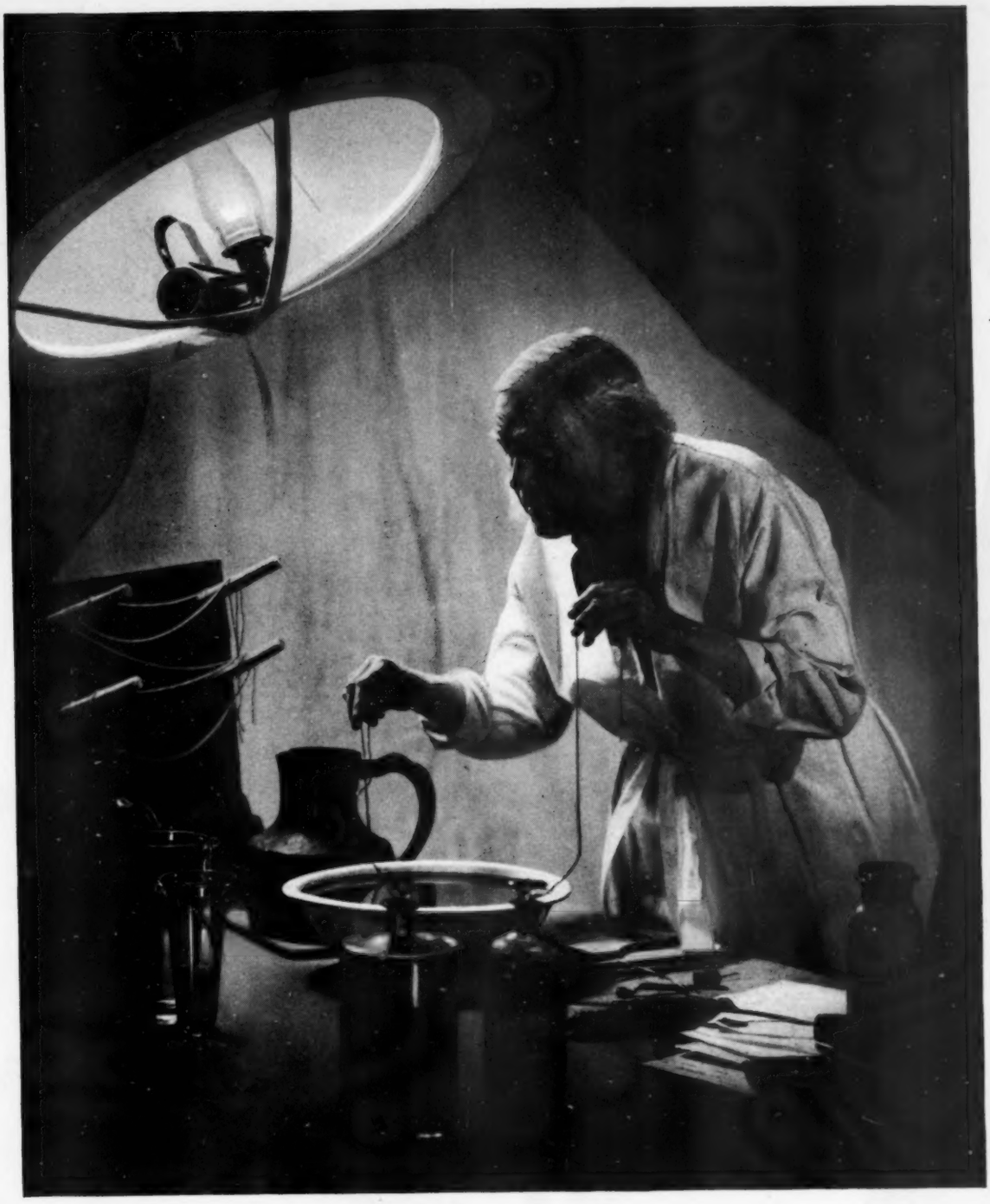

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Complications of Suturing (continued)

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Skin wound bulges over separated tissues beneath

If above signs are present remove one or two sutures and inspect beneath

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Causes of Evisceration

Insecure closure and Failure of Healing of peritoneum and posterior sheath.

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   - a. Tissues thin – sutures tear out easily
   - b. Necrosis of tissues
   - c. Unusual strain
   - d. Sutures rapidly absorbed
   - e. Knot becomes untied

2. **Failure of Healing . . .**

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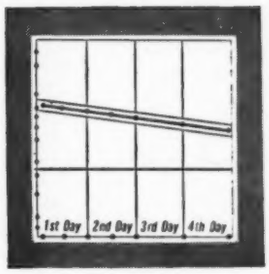

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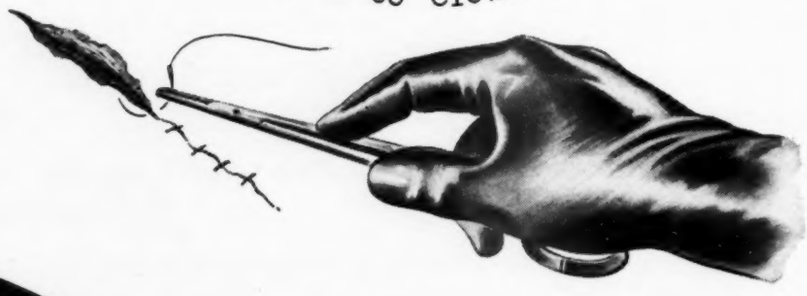

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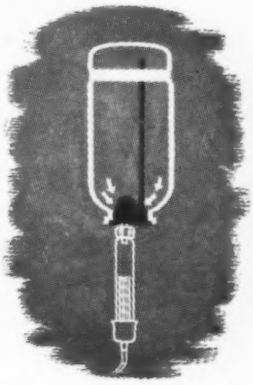

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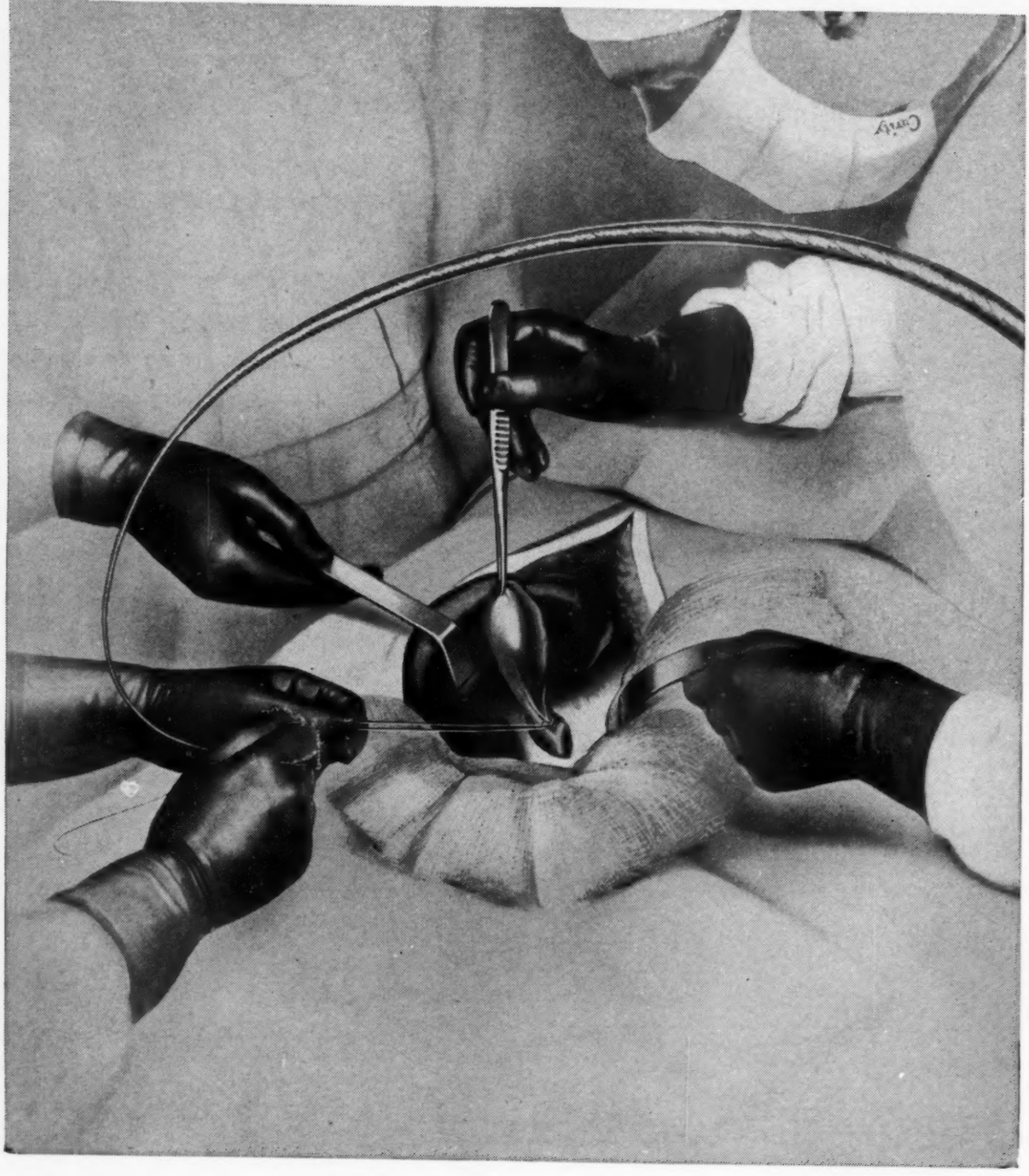

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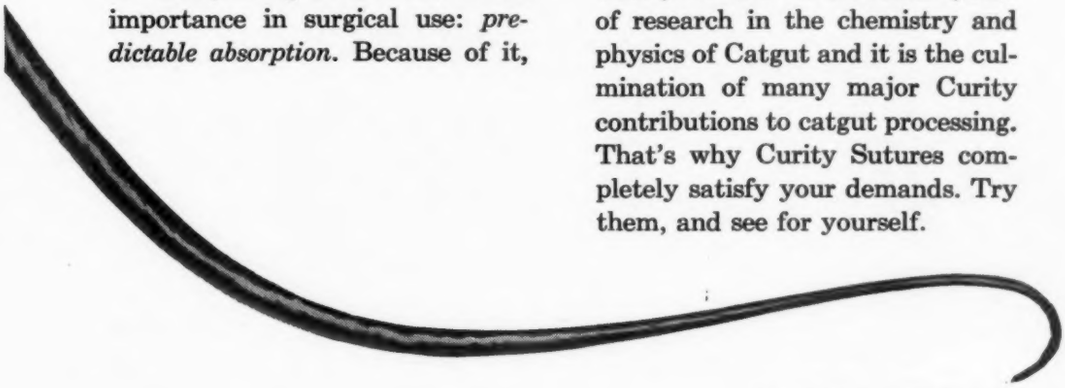

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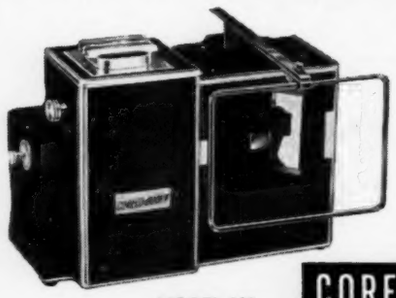

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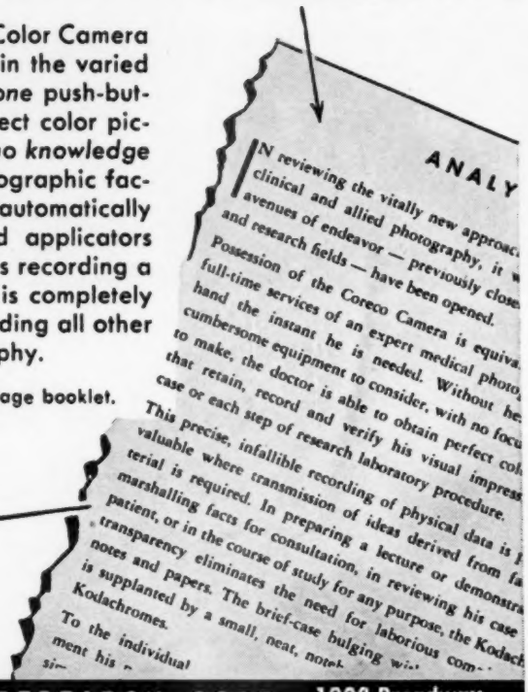

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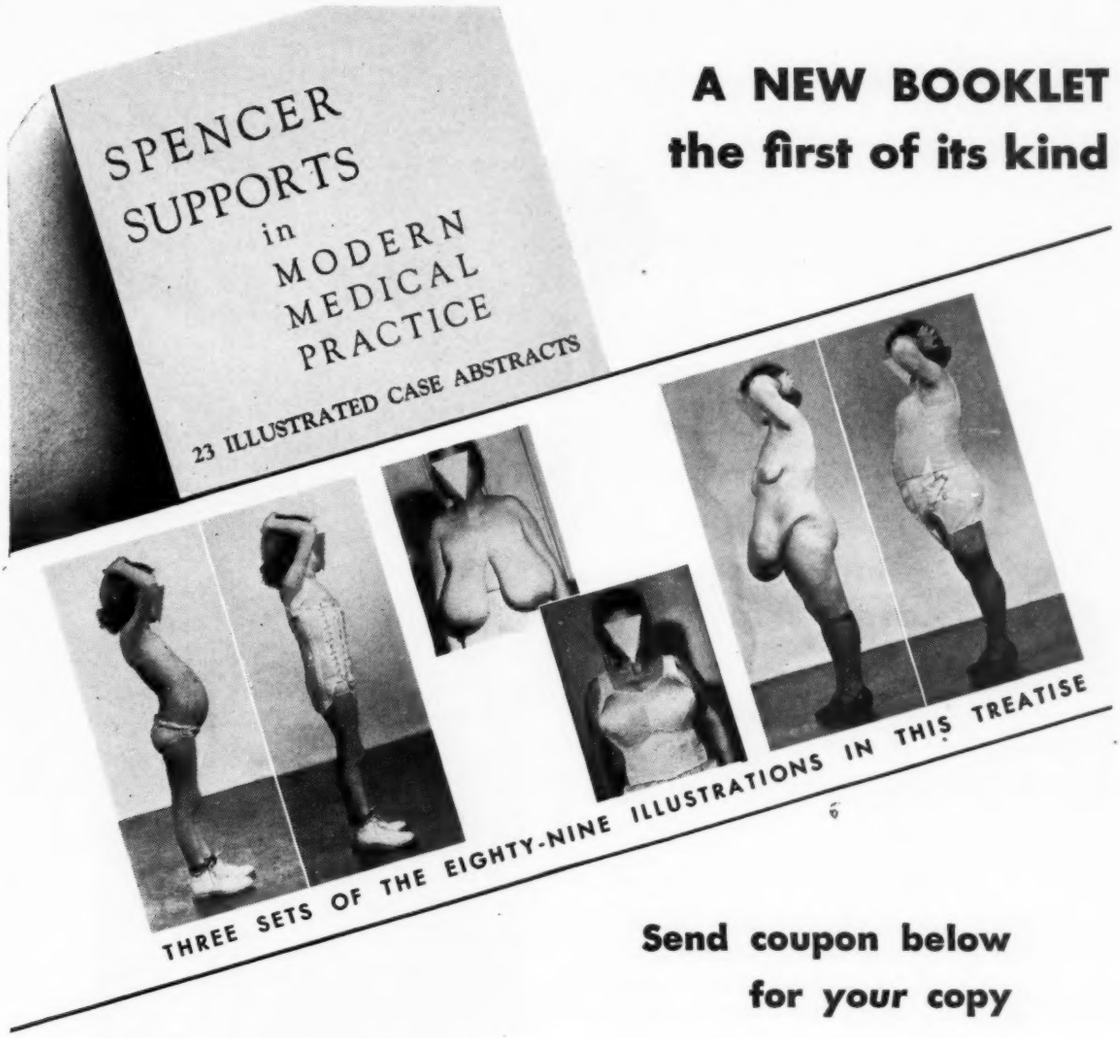

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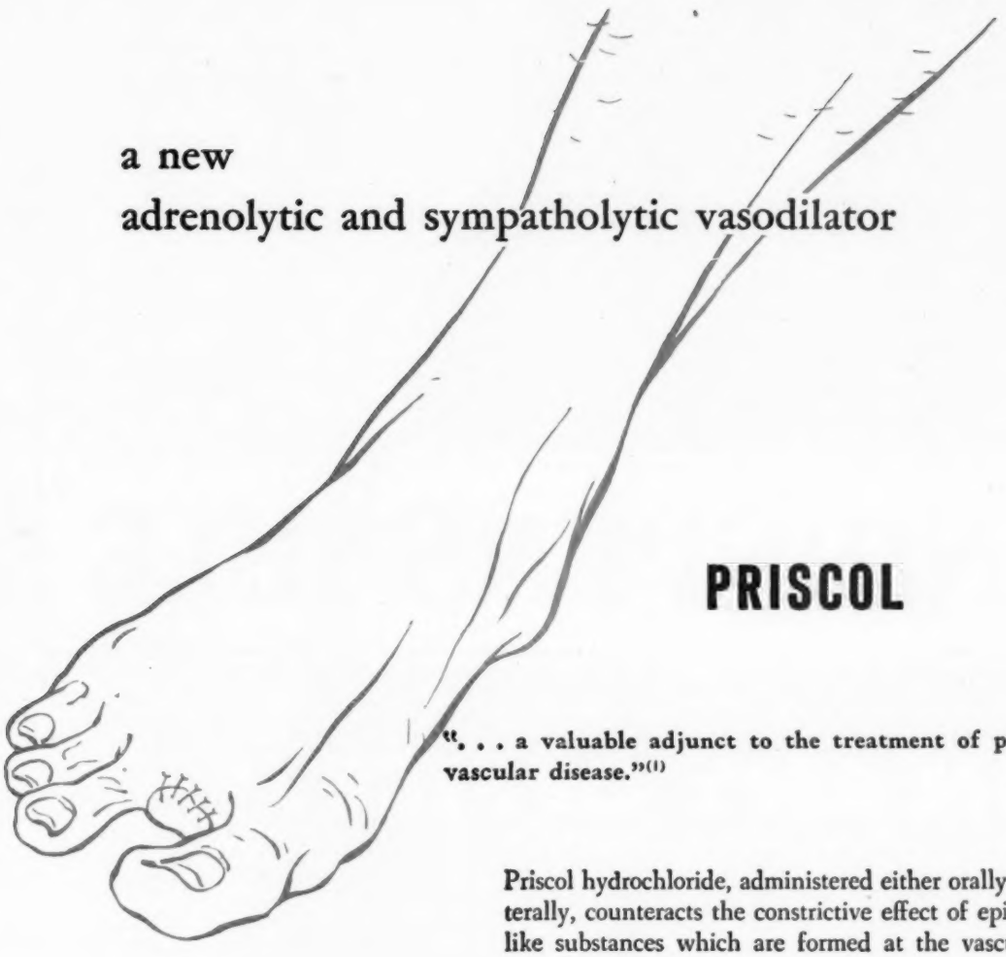

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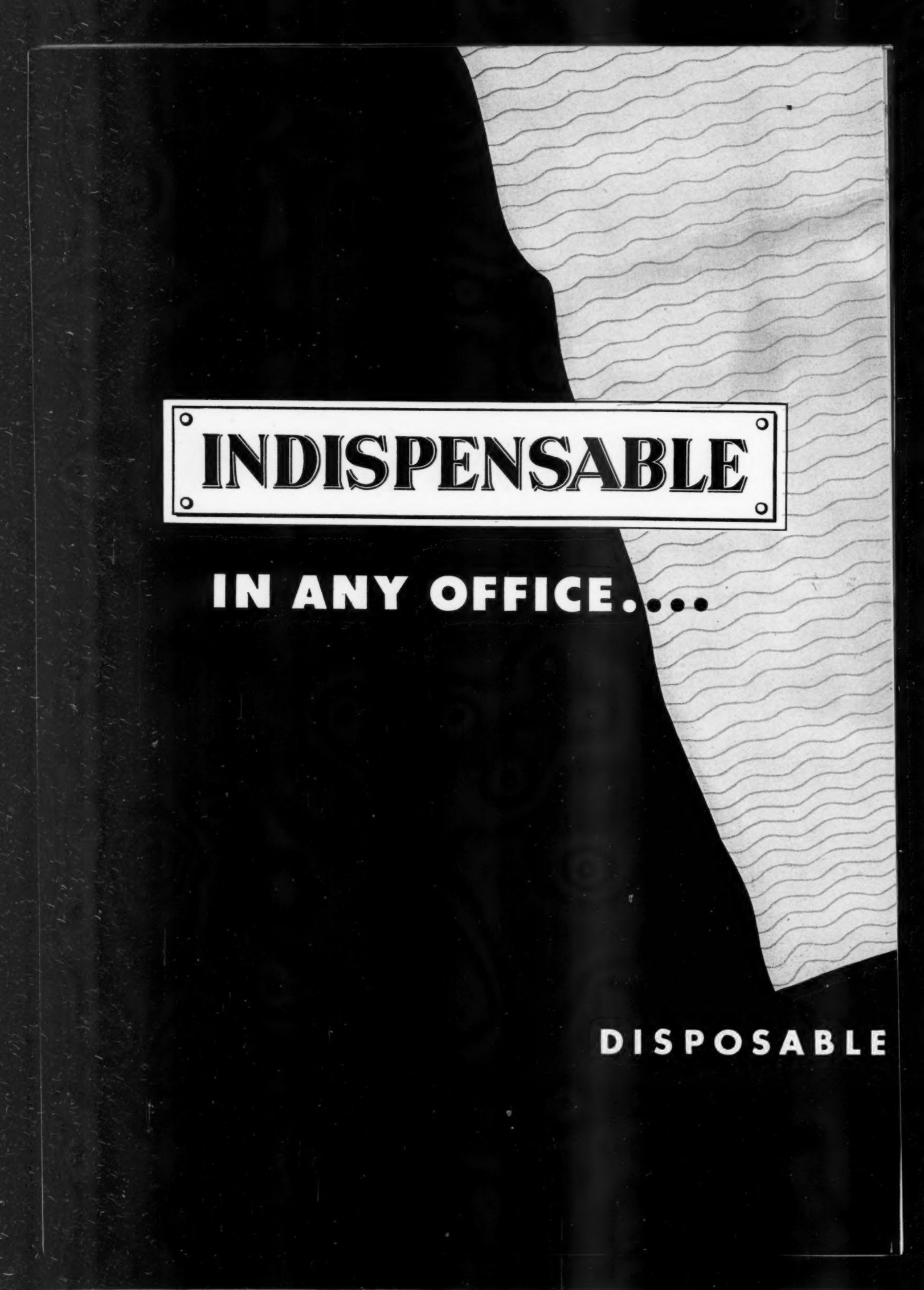
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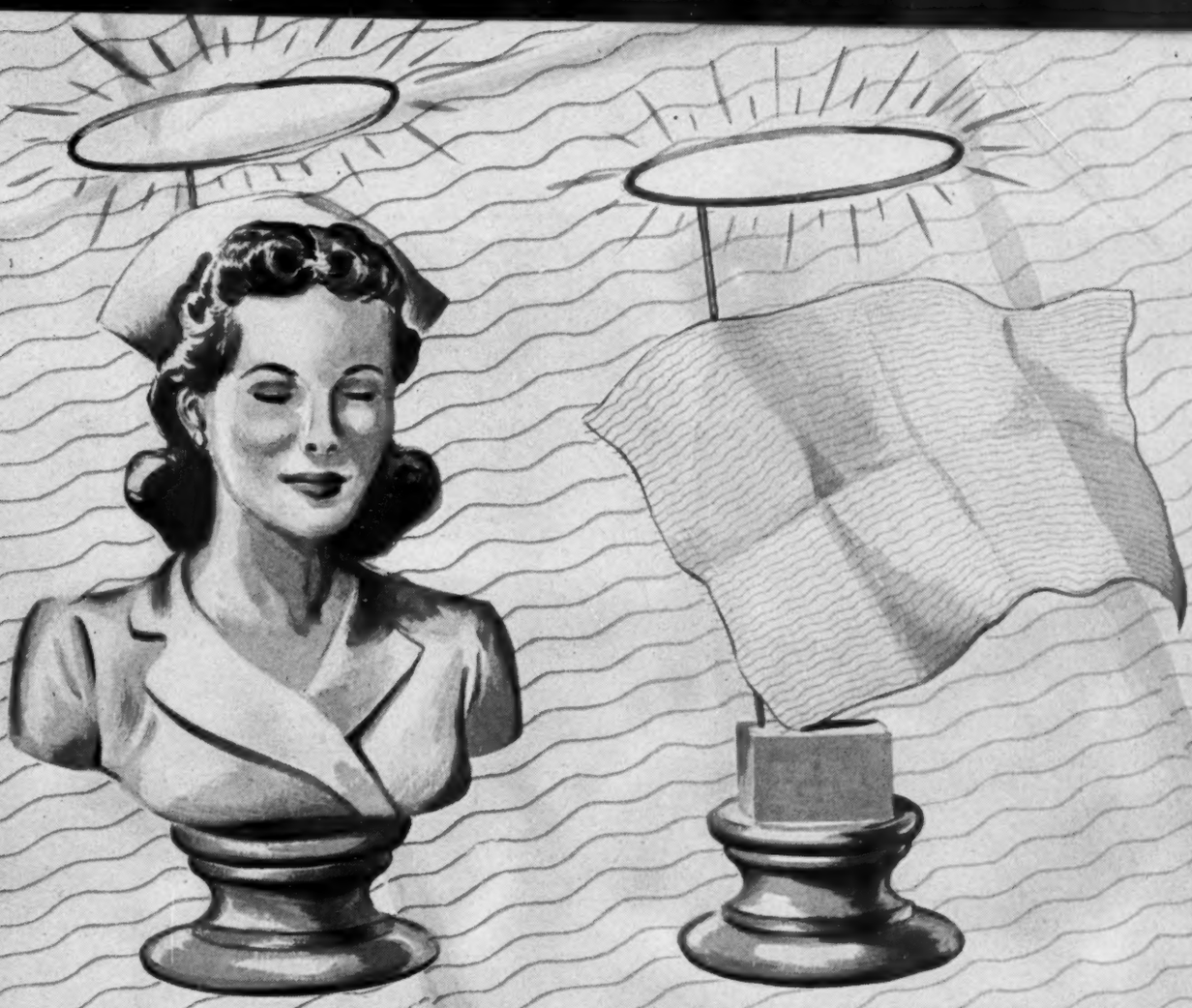

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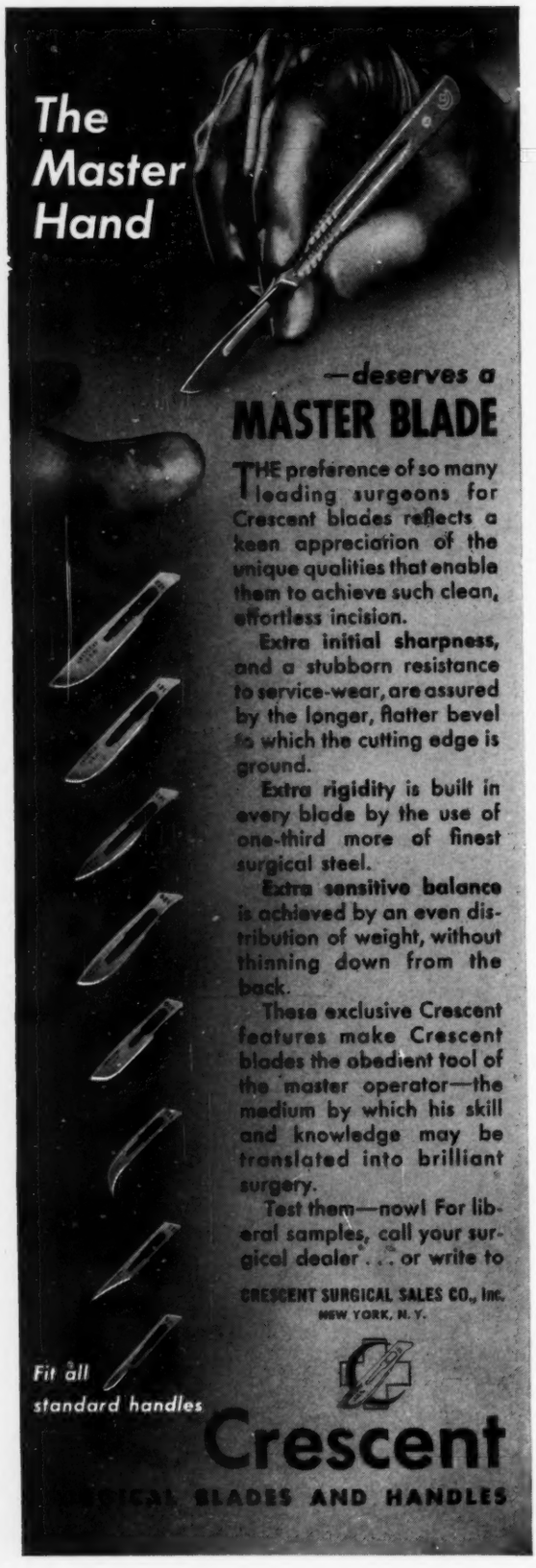
The Master Hand
—deserves a
MASTER BLADE
THE preference of so many leading surgeons for Crescent blades reflects a keen appreciation of the unique qualities that enable them to achieve such clean, effortless incision.
Extra initial sharpness, and a stubborn resistance to service-wear, are assured by the longer, flatter bevel to which the cutting edge is ground.
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These exclusive Crescent features make Crescent blades the obedient tool of the master operator—the medium by which his skill and knowledge may be translated into brilliant surgery.
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CRESCENT SURGICAL SALES CO., Inc.
NEW YORK, N. Y.
Fit all standard handles
Crescent
SURGICAL BLADES AND HANDLES

Tales and Details

"Man bites dog" should be the title of this column — because one of my hospitals has just been selling ME— on Saftiflask Solutions (and how I like it).

It's a grand and glorious feeling, because only about a year ago, this same hospital was making its own solutions. I felt plenty set-up when I got them to stop kidding themselves about the costs they were "saving." But I guess the real selling credit should go to Saftiflasks, once they were on the job.

One nurse said to me, "Why didn't you tell us? Life's so much simpler with this expendable I. V. set — no assembling or sterilizing to do. When we're through with an I.V., we can throw the whole outfit away."

A nurse (in central supply) said, "You can't imagine the convenience of having ready-prepared solutions— and this new Cutter label, where the name of the solution really stands out, saves a lot of grief too."

In fact, it seems like everybody had his own pet reason for liking Saftiflasks: the soft rubber stoppers make it easy to plug in injection tubing and hold it securely — the metal connector on the set doesn't shatter — the plastic observation tube gives you a quick check to see whether the solution is flowing into the vein.

Then, when I got to talking with one of the staff medics, he announced, "We can verify the solution before administration now, without standing on our heads. No fooling, that new label makes a whale of a difference to us doctors."

You can bet I'd give my shirt to have a recording of that visit — to take around to some of the other folks who are still making their own solutions. It would make my selling job as easy as—well, as giving I.V.'s with the Saftiflask set-up.

Your CDM
(Cutter Detail Man)

Cutter Laboratories • Berkeley 1, Calif.

INSTRUMENTS OF AUTHENTIC DESIGN

FOR GENERAL SURGERY

The instruments shown above are typical of the large number designed by leading surgeons for operative or diagnostic use in the field of general surgery, and made by Pilling craftsmen. No finer instruments are obtainable.

A. P12498 Babcock Needle Holder; useful with wire sutures.

B. P13670 Babcock Sump Drains, Stainless Steel.

C. P18282 Rectal Retractor, T. Chittenden Hill.

D. P20667 Rock Endometrial Curette.

E. P20912 Wilson Amniotic Trochar.

F. P21322 Douglas Measuring Plate.

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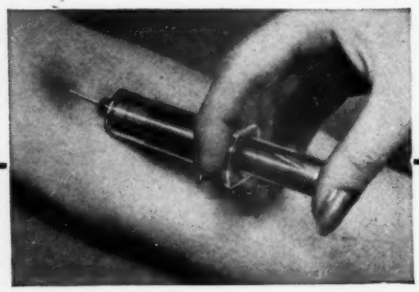
PILLING FOR PERFECTION in surgical instruments

BLOOD SPECIMENS IN LESS THAN 7 SECONDS

without Hemolysis



when you use the

B-D **VACUTAINER®**
(A SPECIMEN TUBE)

AND NOTE THESE ADVANTAGES—

1. **SPEED**—10cc of Blood in less than 7 seconds—under normal conditions. Speed of Vacutainer may permit one technician to do the work of two using other methods.

2. **LOW COST**—Original cost of equipment compares favorably with any other method. B-D Vacutainer saves cost of syringe, tube, cork, washing, scouring, sterilization, and other preparations for use. Less handling means less danger of breakage.

3. **CLEANLINESS**—Closed container eliminates contamination or possible spillage. Excess vacuum, after sufficient quantity of blood is taken into tube, automatically sucks residual blood from needle cannula into Vacutainer.

4. **NO BLOOD TRANSFER NECESSARY**—Blood is drawn from vein through needle into Vacutainer—where it remains for centrifuging and tests without need of transfer, also eliminating danger of outside contamination.

5. **ADAPTABILITY**—B-D Vacutainer tubes are available in a variety of sizes to fit most standard tests. They are supplied with or without anti-coagulant.

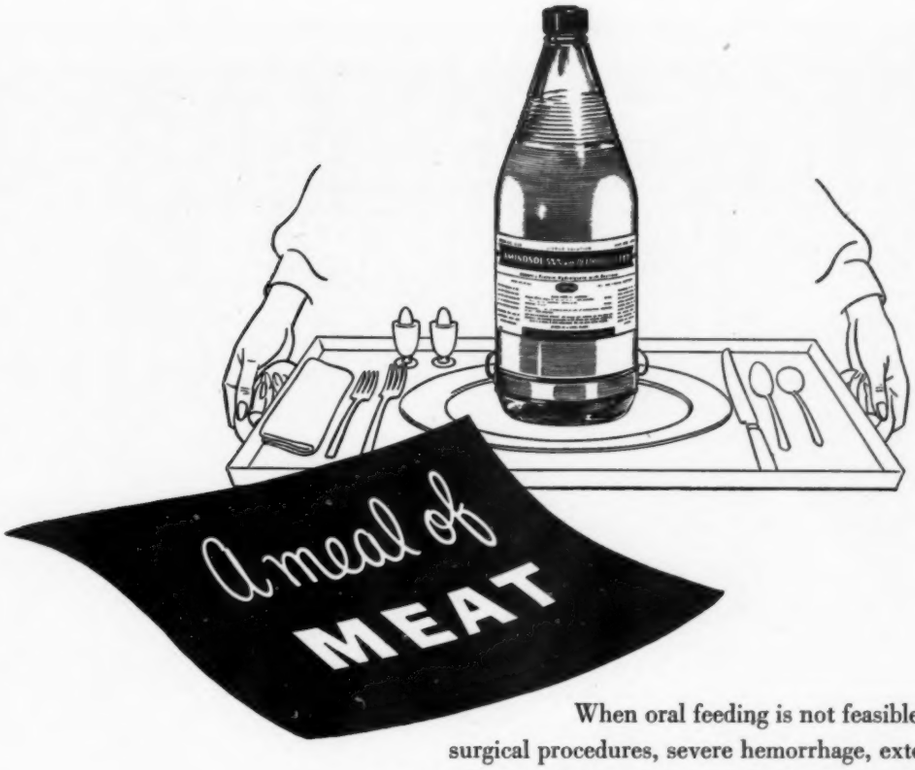
6. **HIGH QUALITY OF BLOOD**—Delivers the quality and quantity of blood to the laboratories that they have always wanted but have not always received.

"Built to Handle Like a Syringe"

Literature on Request

B-D PRODUCTS
Made for the Profession

BECTON, DICKINSON & CO., RUTHERFORD, N. J.



When oral feeding is not feasible following surgical procedures, severe hemorrhage, extensive burns or gastrointestinal disturbances, depend on the efficiency and safety of Abbott's protein hydrolysate, AMINOSOL 5% with Dextrose 5%.

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AMINOSOL is sterilized by autoclaving. In addition, it is biologically tested for its ability to promote growth and to maintain nitrogen balance, for absence of antigenicity and for absolute freedom from pyrogens. It is stable at room temperatures for two years or longer.

AMINOSOL is supplied in 500-cc. and 1000-cc. Abbott Intravenous Solution Containers, ready to use. Obtain added safety and convenience by using the sterile, disposable VENOPAK* equipment. ABBOTT LABORATORIES, North Chicago, Illinois.

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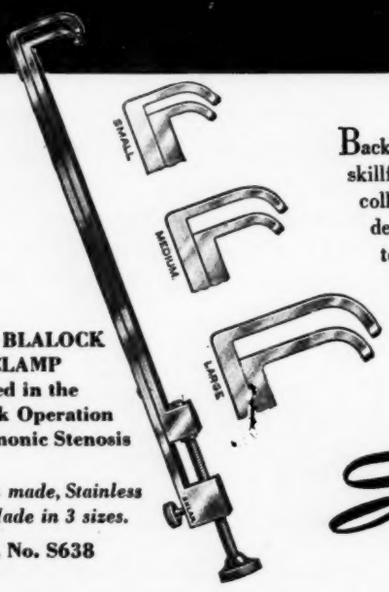
Aminosol® 5%

WITH DEXTROSE 5%

Abbott's Modified Fibrin Hydrolysate 5% with Dextrose 5%

1. Christensen, H. N., Lynch, E. L., Decker, D. G., and Powers, J. H. (1947), The Conjugated, Non-Protein, Amino Acids of Plasma. IV. A Difference in the Utilization of the Peptides of Hydrolysates of Fibrin and Casein, J. Clin. Invest., 26:849, September.

FINE INSTRUMENTS TO SUSTAIN THE SURGEONS' SKILLED HANDS



THE BLALOCK CLAMP used in the Blalock Operation for Pulmonic Stenosis

American made, Stainless Steel. Made in 3 sizes.

Cat. No. S638

Back of the highly developed skill of the surgeon are the skillfully-made instruments by Sklar. Through continued collaboration with leading surgeons, new instruments . . . new designs and engineering . . . new improvements are perfected to meet the needs of advancing surgical techniques.

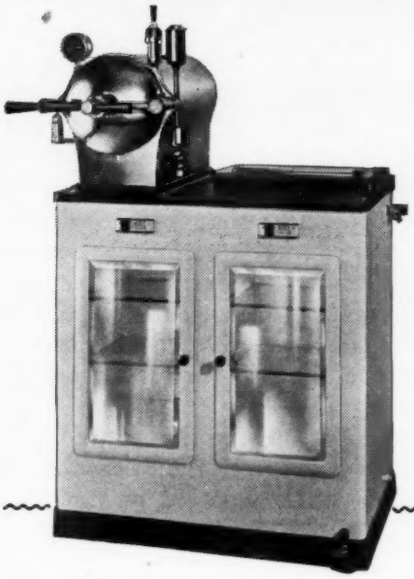
J. SKLAR MANUFACTURING CO. has developed the proper alloys of American-made stainless steel for making the finest of surgical instruments. Today, Sklar manufactures the greatest variety of stainless steel instruments ever made by a single manufacturer.

Sklar **LONG ISLAND CITY, N. Y.**

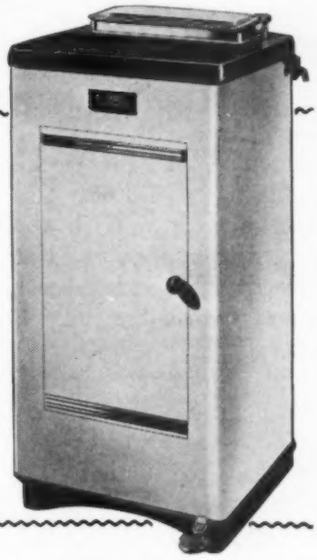
This Signature Marks the Genuine Instrument

SKLAR PRODUCTS ARE AVAILABLE THROUGH ACCREDITED SURGICAL SUPPLY DISTRIBUTORS

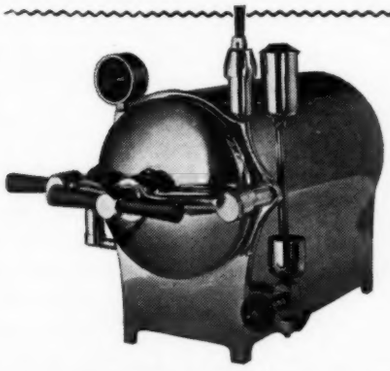
Streamline Your Sterilization Technique WITH CASTLE STERILIZERS



CASTLE "669" INSTRUMENT STERILIZER AND AUTOCLAVE . . . for the absolute sterilizing safety provided only by steam under pressure (250°F). Regular "666" Autoclave (full description below) controllable at selective temperatures for gloves, instruments or dressings. Instrument sterilizer, 16″ x 6″ x 4″, "Cast-In-Bronze," Full Automatic, recessed in double-door storage cabinet. Plate glass shelves in roomy, illuminated interior. Rust-proof aluminum base with toe recess. Convenient, oil check footlift. Extra working space on gleaming black porcelain top.



CASTLE "95" INSTRUMENT STERILIZER . . . ideal for routine service. 16″ x 6″ x 4″ recessed Instrument Boiler, Cast-In-Bronze for long life and "Full-Automatic" for safety. Boiler interior coated with pure block tin to eliminate corrosion. Sloped bottom on boiler permits quick draining through non-clogging draincock. Comes with metal or glass door (95-G). Illuminated interior with 2 removable plate glass shelves. Convenient, trouble-free, oil check foot-lift. Non-rusting aluminum base with toe recess.



CASTLE "666" AUTOCLAVE . . . a space-saver, easily installed, can be set on a table or supplied with stand. "Full-Automatic" control simplifies operation. Super-safety with Cast-In-Bronze construction. Easy to clean, sparkling chrome finish outside, fully coated inside with solid tin to eliminate corrosion. Steam jacketed, automatic air ejector, steam gauge and safety valve with new type steam silencer. 6′ cord and switch.

For full details, see your Castle dealer or write: Wilmot Castle Company, 1149 University Ave., Rochester 7, N.Y.

Castle LIGHTS AND STERILIZERS

Outside the Ivory Tower

THE Women's Medical Specialist Corps of the regular army consists of dietitians, physical therapists and occupational therapists. This corps is new to the army only in name for the specialists comprising this group have served with the Medical Department for the past thirty years. In recognition of the outstanding professional contribution made by these three groups of specialists in the care and rehabilitation of the sick and wounded during World War II, The Surgeon General of the Army recommended to the War Department that legislation for a permanent military status be given consideration. Public Law 36, 80th Congress, signed by the President on April 16, 1947, authorized the establishment of a Women's Medical Specialist Corps in the regular army and also a section in the Officers' Reserve Corps. With the enactment of this law, dietitians, physical therapists and occupational therapists have become a permanent part of the regular amy, a position of security and recognition justly deserved. In well equipped military hospitals in this country and overseas these officers now have an opportunity not only to contribute to the care of the sick but also to further their own professional advancement while leading a full and interesting life.

DR. H. Houston Merritt, a pioneer in epilepsy research, was named as professor of neurology and executive officer of the department of neurology of the Faculty of Medicine of Columbia University, and as director of the neurologic service and attending neurologist, Neurological Institute, Presbyterian Hospital. The announcement was made by General Dwight D. Eisenhower, president of Columbia University, and Charles P. Cooper, president of the Presbyterian Hospital. Before coming to the Neurological Institute of the Columbia-Presbyterian Medical Center for this new appointment Dr. Merritt was for four years chief of the division of neuropsychiatry at Montefiore Hospital.

SMALLPOX is rapidly approaching extinction in the United States. In 1947 there were only 173 cases of the disease reported in the entire country, as compared with 356 cases the year before and with 11,673 in 1937. This is a reduction of more than 50 per cent in a single year and of more than 98 per cent in a decade. Furthermore, progress in the eradication of smallpox is continuing; in the first twenty weeks of 1948 there were only forty-five cases, about one-third the corresponding figure of a year ago.

Seventeen states and the District of Columbia were entirely free from the disease in 1947 while six other states reported only one case each.

VETERANS Administration today urged all veterans who were treated for syphilis with penicillin during service in the armed forces to undergo periodic check-ups so as to prevent recurrence of the disease. Between 20 and 30 per cent of those treated with penicillin are reported to be "failures," contrary to the popular belief that the drug is a "cure all" for venereal disease, Dr. Bascom Johnson, Jr., assistant chief of dermatology and syphilology in the Veterans Administration's Department of Medicine and Surgery, declared. Veterans who suffered from this disease are urged to report to their private physician or their local health department.

AS a cause of death diabetes mellitus has risen from twenty-seventh to eighth place since 1900. It is estimated that there are between 675,000 and 1,000,000 diabetics in this country, with at least 50,000 new cases each year. These significant figures are quoted from a statement made by Dr. Rufus S. Reeves, Director of the Philadelphia Department of Public Health, in his introduction to the newly published *Diabetic's Handbook* by Anthony Sindoni, Jr., M.D. This authoritative handbook has been issued by The Ronald Press Company, Publishers, New York, N. Y.

(*continued on page* 34)

Vodine
BRAND
IODINE SOLUSALVE*

ALL THE ADVANTAGES OF IODINE IN A NON-IRRITATING BASE

Danger of surface infection can be effectively combated with Vodine Brand Iodine Solusalve which exerts powerful bactericidal and fungicidal actions without smarting, stinging or staining. By incorporating iodine—one of the most potent germicidal agents—in a special bland, water-miscible base, Vodine Brand Iodine Solusalve is effective not only on skin surfaces, but also on open wounds.

Vodine—2% iodine in Solusalve—is not injurious to even the most delicate skin. It does not smart or sting and prevents surgical dressings from sticking to wounds.

To prevent surface infection, without causing painful smarting or stinging, use and prescribe Vodine Brand Iodine Solusalve.

Samples and brochure sent upon request.

Vodine Company

407 South Dearborn Street, Chicago 5, Illinois

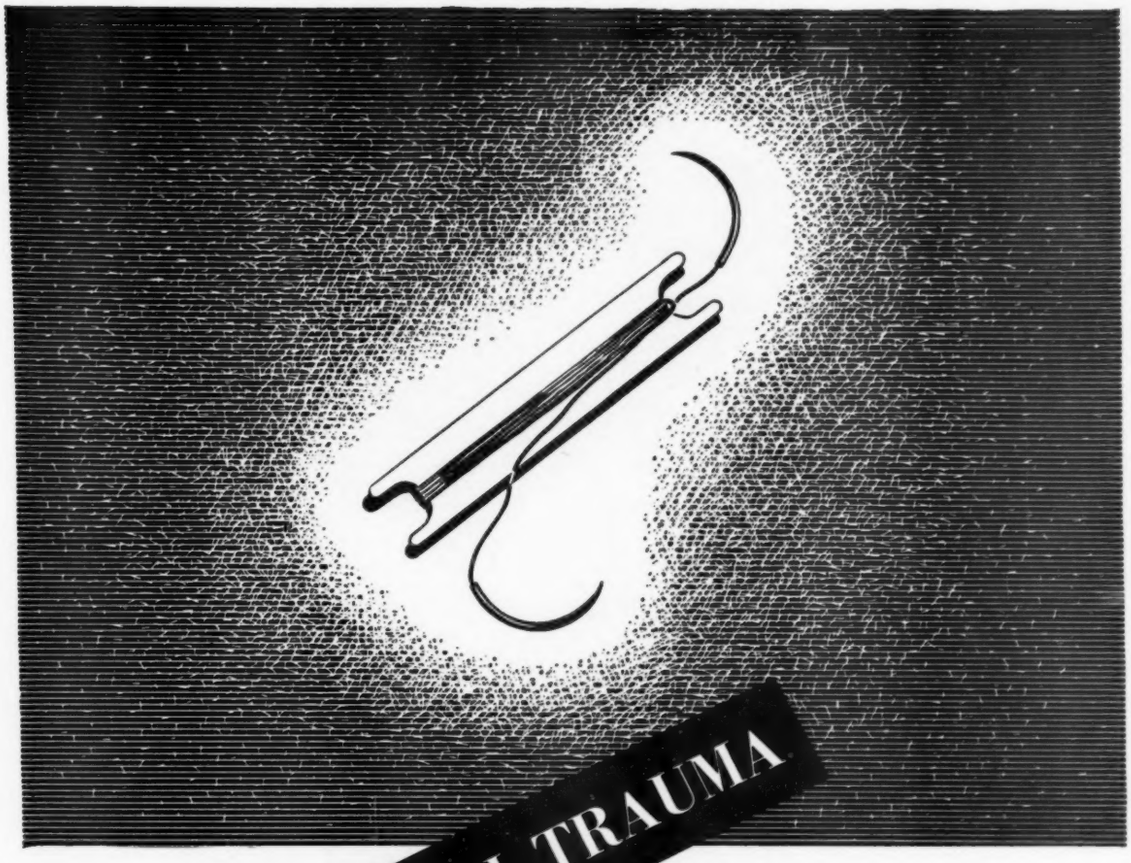
For surface infections . . .

FURACIN"1
SOLUBLE DRESSING
(BRAND OF NITROFURAZONE)
CONTAINS 0.2% NITROFURAZONE (5-NITRO-2-FURALDEHYDE SEMICARBAZONE) IN A WATER SOLUBLE BASE.
CAUTION: TO BE DISPENSED ONLY BY OR ON THE PRESCRIPTION OF A PHYSICIAN.
DESCRIPTION OF PRODUCT AND USES AVAILABLE TO PHYSICIANS ON REQUEST.
AN ANTIBACTERIAL PREPARATION FOR TOPICAL APPLICATION
EATON LABORATORIES Inc.
NORWICH, NEW YORK
ONE POUND, AVOIR.

Although burned tissues supply an excellent medium for bacterial growth, infection may be minimized by the prompt, topical application of an efficient antibacterial agent. For this purpose, fine-mesh gauze strips impregnated with Furacin Soluble Dressing may be used. The effectiveness of Furacin in combatting mixed infections of burns without delay of healing has been well demonstrated.* Furacin N.N.R., brand of nitrofurazone, is available as Furacin Soluble Dressing and as Furacin Solution, both containing 0.2 per cent Furacin.® These preparations are indicated for topical application *in the prophylaxis and treatment of infections of* wounds, second and third degree burns, cutaneous ulcers, pyodermas and skin grafts. *Literature on request.*

EATON LABORATORIES, INC., NORWICH, N.Y.

*Snyder, M. L., Kiehn, C. L. and Christopherson, J. W.: Mil. Surgeon, *97*: 380, 1945. • Shipley, E. R. and Dodd, M. C.: Surg., Gynec. & Obst., *83*: 366, 1947 • Mays, J. L.: J. Med. Assoc. Georgia, *36*: 263, 1947. • Curtis, L.: Surg. Clin. N. America, 1466 (Dec.) 1947.



FOR MINIMAL TRAUMA

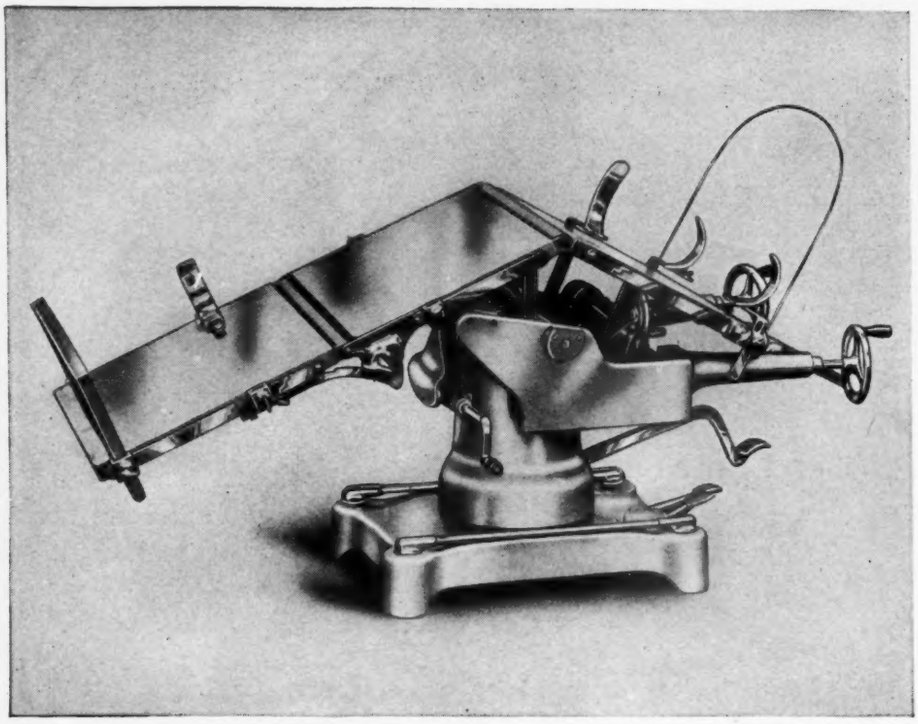
For eye surgery, plastic repair, and other delicate procedures in which minimal tissue trauma is essential, Champion MINTRAUMATIC SUTURES complement the technique of the skillful surgeon.

Champion MINTRAUMATIC SUTURES have eyeless (swaged on) needles which make it possible to suture with a single strand of material. Available in Serum-Proof Silk, single arm or double arm, or Champion Dermal with single arm, in sizes 000 to 00000.

SPECIFY Champion **MINTRAUMATIC Sutures**

Available through leading surgical supply dealers.

GUDEBROD BROTHERS SILK CO., INC.
225 West 34th Street, New York 1, N. Y.



New! Hermann Operating Table by Shampaine!

The Hermann Major Operating Table, S-1506, is the result of careful surgical research and Shampaine engineering skill—combined to provide unique features not available on any other table.

- **EXTREME KIDNEY POSITION** of 130° at minimum 32″ height eliminates need of kidney elevator and footstool—provides complete body support to extremities.
- **SINGLE CONTROL ADJUSTMENT** from kidney to reflex abdominal positions facilitates closure of body opening for suturing.
- **LOW 90° CHAIR POSITION** at 26″ minimum height — ideal for brain and EENT surgery.
- **HEAD END CONTROL** of most important adjustments by the anesthetist.

The above and other outstanding features of the new **Hermann Major Operating Table** justify immediate investigation.

Sold through Surgical and Hospital Supply Dealers.

SHAMPAINE CO. ST. LOUIS MISSOURI

Greatly Simplifies Anorectal Surgical Procedure

The Helfrick
ANAL RETRACTOR

affords unprecedented depth of exposure of the operative site to a degree which permits visualization of all varicosities in the hemorrhoidal area.

HIGHLIGHTS OF CLINICAL IMPORTANCE

In providing firm traction of the four quadrants of the peri-anal tissue, the surgeon is assured of a free, unobstructed surgical approach.

Facilitates greater speed in attaining a satisfactory surgical objective. Sutures need only be tied to the four equi-distant cleats on the ring to effect deep-exposure traction.

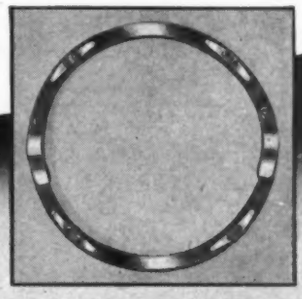
Also permits visualization of intermediate veins, the removal of which may often eliminate the need for further surgery should they become enlarged at a later date.

A collapsible feature, permits the semi-anular members of the stainless steel Anal Retractor to be readily and compactly folded for immersion in a small instrument sterilizer, kit bag or instrument cabinet.

ELIMINATES ANY NEED FOR ONE OR MORE ASSISTANTS* ... a valid consideration in emergency cases or in rural areas where hospitalization offers a problem.

*Helfrick, J. Rembrandt: Amer. Jour. Surgery 70-1:131-132, October, 1945

TRADE MARK



A Kny-Scheerer quality instrument, precision-made for discriminating surgeons.

ORDER THROUGH YOUR DEALER
or write for descriptive literature.

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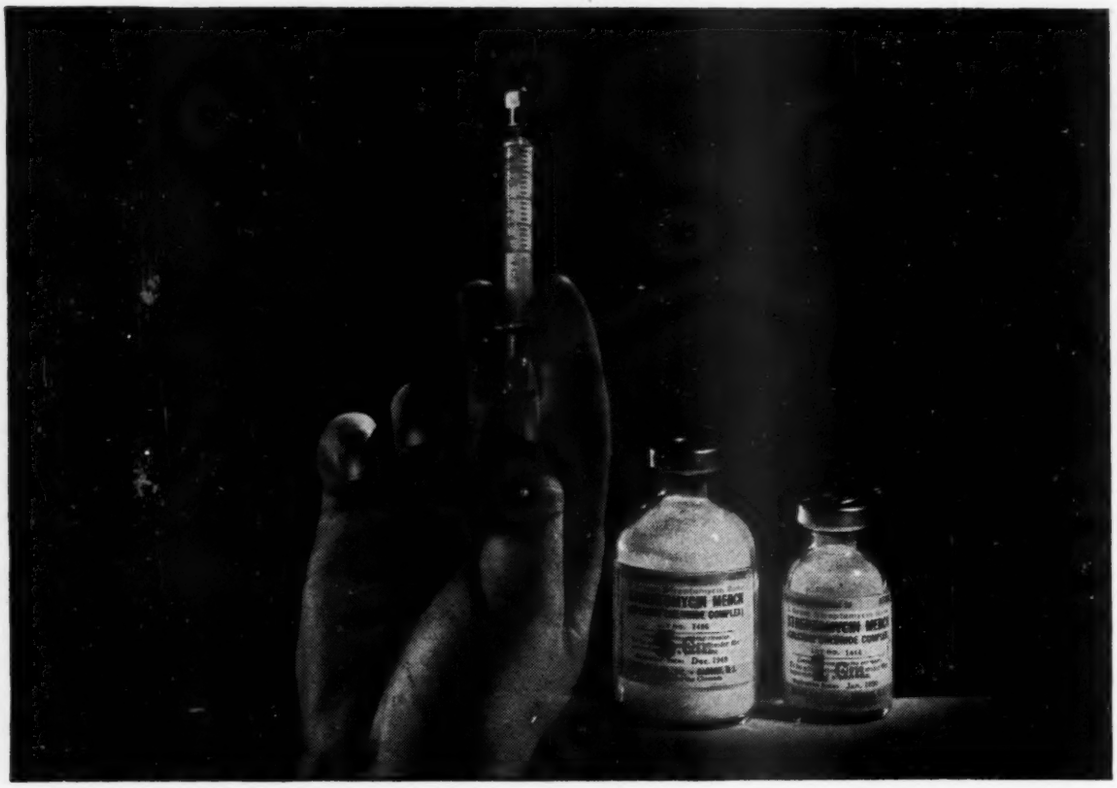

To Facilitate Preparation of Solutions...

For greater convenience and economy, both important considerations, Streptomycin Calcium Chloride Complex now is supplied in a multiple-dose container, 5 Gm. in a 50 cc. vial.

DILUTION TABLE*

For Vials Containing the Equivalent of 1 Gm. or 5 Gm. Streptomycin Base (See Label)

Solvent added to 1-Gm. vial		Streptomycin base per cc.		Solvent added to 5-Gm. vial		Streptomycin base per cc.	
19 cc.	5.5 cc.	50 mg.	150 mg.	45.5 cc.	12 cc.	100 mg.	300 mg.
15.5 cc.	4.5 cc.	60 mg.	185 mg.	35.5 cc.	9.5 cc.	125 mg.	350 mg.
9 cc.	4 cc.	100 mg.	200 mg.	28.5 cc.	8 cc.	150 mg.	400 mg.
7 cc.	3 cc.	125 mg.	250 mg.	20.5 cc.	6.5 cc.	200 mg.	450 mg.
				15.5 cc.	5.5 cc.	250 mg.	500 mg.

For Streptomycin of the Highest Quality—Specify

STREPTOMYCIN
CALCIUM CHLORIDE COMPLEX
MERCK

Council ACCEPTED COUNCIL ON PHARMACY AND CHEMISTRY AMERICAN MEDICAL ASSOCIATION *Accepted*

MERCK & CO., Inc. *Manufacturing Chemists* RAHWAY, N. J.

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** Printed copies of this Dilution Table are available on request.*

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ACR-ALLANTOMIDE

OINTMENT

The newest

in the chemotherapy of wounds

The antiseptic properties of the acridines have been known for some time and 9-aminoacridine is one of the most useful.

In Acr-Allantomide Ointment 9-aminoacridine is combined with sulfanilamide. Thus, full use is made of the natural synergism that exists when these two potent antibacterial agents are combined.[1,2]

Acr-Allantomide Ointment offers these important advantages:

1. It is effective against an extremely wide bacterial spectrum.
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3. It is non-injurious.
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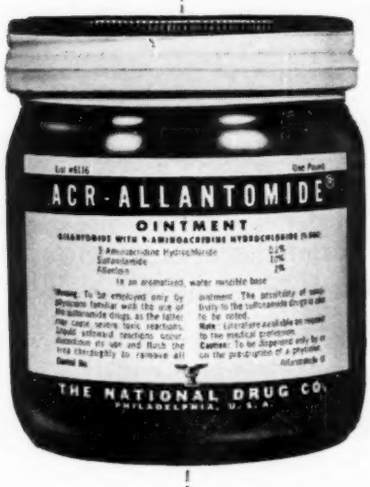

Acr-Allantomide Ointment is intended for use in the local treatment of wounds, topical ulcers, burns and related surgical conditions. It is also of value in dressing boils, carbuncles and infected lesions.

[1] Martin, G. J. & Moss, J.: Proc. 111th Meeting A. S. C., p. 2B. Atlantic City, N. J. (April 14-18) 1947.

[2] Spotts, S. D.: Am. J. Surg. 2:183 (Aug.) 1947.

ACR-ALLANTOMIDE OINTMENT IS AVAILABLE IN 1 OUNCE TUBES AND 1 POUND JARS. DESCRIPTIVE LITERATURE AND SAMPLES WILL BE SENT ON REQUEST.

THE NATIONAL DRUG COMPANY PHILADELPHIA 44, PENNA.

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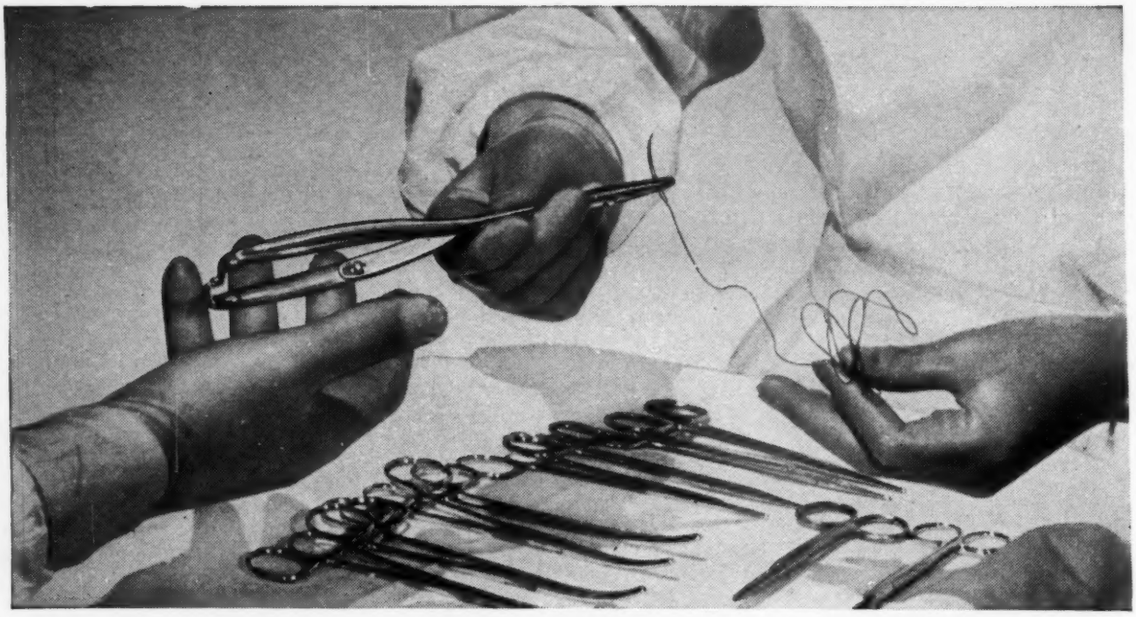

Now You Can Use Ethicon Swaged Needle Sutures at No Extra Cost

Nonbreakable Sterile Pack canister contains Ethicon Swaged needle sutures, ready to use.

Supplied at Same Price as Standard Tubes

Surgeons and hospitals applauded the recent Ethicon announcement that prices are now the same for Atraloc Needle Sutures as for Standard Tubes. (Double-armed sutures also reduced in price.)

This substantial saving has encouraged many to greatly increase their use of our needle sutures and to benefit from refined technics and simplified handling.

Hospitals save in many ways

Sterile Pack canisters permit hospitals important savings realized from this modern package. Now surgeons can use G-I., Ob. & Gyn., Tonsil and Circumcision Sutures in Sterile Pack —same prices as Standard Tubes.

Ethicon's Atraloc swaged-needle sutures eliminate needle threading and give the surgeon optimum suturing facilities.

For the hospital, needle buying and handling problems are eliminated. Sterile sutures and needles are always ready for instant use.

In the O.R., nurses' valuable time is saved. Faster, smoother surgery is accomplished.

Ask your O.R. for Ethicon Swaged Needle Sutures

ETHICON *Sutures*

ETHICON SUTURE LABORATORIES
DIVISION OF JOHNSON & JOHNSON, NEW BRUNSWICK, N. J.

The American Journal of Surgery

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A PRACTICAL JOURNAL BUILT ON MERIT

Fifty-seventh Year of Publication

VOL. LXXVI NOVEMBER, 1948 NUMBER FIVE

Editorial

PRESIDENTIAL ADDRESS

CASPER F. HEGNER, M.D.

Denver, Colorado

SELF-PRESERVATION, the first law of animate creation, has a corollary, the relief of pain and the prevention of disability. During the dawn of civilization primitive care of the injured became the inception of surgery of a traumatic condition.

The surgery of an acute traumatic condition, the first and for many centuries the most important if not the only surgery, should today be the most advanced, the most highly standardized and the most efficient branch of surgery. Modern experience disproves this logical deduction. The surgery of a traumatic condition has not kept pace with the progress made in other branches of surgery. It lags because it is not receiving the consideration its universality and urgency demand.

The next surgical advance must be made in the field of traumatology. This is the prime purpose of our Association. To fully achieve this laudable purpose all factors pertaining to the prevention of accidents, and the general and local care of the injured must be explored, expanded and developed to the highest attainable degree.

Surgery in general, more particularly the surgery of traumatic conditions, is greatly indebted to military surgery. The experiences and technics gained during the varied campaigns in the wars of many nations have proved their value through decades of civilian practice. Many surgeons became resourceful, versatile masters of emergencies under adverse conditions and harrowing stresses incident to combat and during the confounding confusion attending the often unpredictable movement of large bodies of troops.

The plan first put into practice by Larrey during the Napoleonic Wars was developed into the most efficient program of all military history by the leaders of the United States Army Medical Corps during the late war—the on the spot first aid and protective treatment of battle casualties, the brilliant work of the unsung heroic stretcher bearers removing under fire the injured from the battlefield to the forward dressing stations for supportive therapy and imperative surgery, the prompt ambulance transportation to mobile field hospitals for emergency surgery and classification of injuries so that they may be distributed to base hospitals for definitive or specialized surgery and later if necessary to rehabilitation centers. This comprehensive and efficiently executed program established a record unequaled in military annals and unexcelled in civilian practice anywhere at anytime. The efficient care of the wounded is the only humanizing influence of wars. The care of the wounded by the Allies attained the ultimate in the late war.

Wars have taught that the surgery of traumatic conditions is not a specialty *per se*. It is basic. It is the vital part of every surgical specialty. It encompasses the whole body, covers every tissue, every system, every

cavity. Wars have taught that all who treat human ills or injuries should be qualified to handle traumas of any part of the body at least by adequate temporary protective dressings which would prevent additional damage or complications during transportation and until the time of receiving more efficient or definitive treatment. Furthermore, in the management of traumas no amount of definitive surgery however expert or highly specialized can achieve its best results without competent antecedent care. The best definitive surgery, the most ingenious revision operations cannot fully compensate for the damage compounded by or the complications consequent to overzealous, injudicious or careless early care.

These are the lessons the late war has taught. Are we to continue to be insensible to these invaluable experiences gained through suffering, blood and sweat and not apply them to the civilian teaching, training and practice of the surgery of traumatic conditions?

Modern traumatology, the science of wounds and injuries, presupposes a knowledge of anatomy, physiology, pathology and bacteriology. It imposes an accurate evaluation of the local damage, the reaction of the tissues in the area affected, an appreciation of the possible immediate and delayed complications and a careful consideration of the general physical and psychic reaction of the host to the local damage. It further implies an understanding of the nature, character, direction, duration, intensity and mode of action of the traumatizing force.

The modern treatment of trauma demands thorough, well organized instruction in the fundamental principles of surgery and adequate training experience in the application of these principles that can only be acquired under competent supervision in dispensaries and in receiving and accident wards of municipal, county and industrial hospitals where large numbers of all varieties and grades of casualties are received and treated.

The proper treatment of an acute traumatic condition is to do the correct and safe thing within the limits of ones ability under the limitations imposed by the existing circumstances. It may be (1) immediate or protective, (2) temporary or supportive, (3) delayed or corrective. Each is proper in time and place, each may be improper if time and place are ignored.

Most of our medical schools are woefully remiss in not giving well organized adequate instruction in the basic surgical principles which are fundamental not only to the surgery of traumatic conditions but also to all other branches of surgery. Many schools assume this teaching is sufficiently covered by the courses given in the surgical specialties. More time and attention is devoted to the elective surgery of comparatively rare and uncommon conditions, (gastrointestinal, cerebral, thyroid and chest lesions, tumors and specialized surgical operations) which is indispensible in the training of finished surgeons. These courses could be more advantageously confined to the years of graduate teaching after a thorough foundation in the basic surgical principles has been layed. Too much time and effort is expended on the superstructure and too little is devoted to the foundation of sound medical and surgical education, training and practice. The cursory manner in which these fundamentals are now generally taught is not conducive to good practice. Finished surgeons or specialists cannot be developed from a majority of the medical students in twice the time required for a medical degree. Neither can this be accomplished for the interested promising minority in the few years spent in the very best medical school.

The broader and better the general basic instruction and the more first hand clinical work during the school years the better will be the immediate general and any later special practice. The general practitioners are still the bulwark of better general health, the first, foremost and best defense on the skirmish line against disease and injuries. They constitute a group from which better specialists are recruited.

Each instructor of the surgical specialties plans his course on the erroneous assumption that the basic surgical principles have been previously taught by some other department. He teaches his special branch from the narrow view point of a specialist without regard to the fundamentals common to all branches of surgery. Both surgery in general and the special branches suffer by not being taught in the broader interest of better and more efficient service. The basic principles are the same for both but application of the details and technics differ. The surgery of traumatic conditions

which is highly individualized surgery suffers most by this discrimination.

The hospitals affiliated with medical schools stress training in elective surgical operations and those of the surgical specialties. This is imperative in developing specialists. Many of these hospitals do not have a sufficient number of casualties to justify a department or to allot beds for patients with traumatic injuries, without which they cannot give training or experience in the care of accident patients. There are many more minor injuries handled in a minor manner with major complications than there are major elective surgical cases treated in a major manner without complications. This emphasizes the fact that elective surgery is better taught and surgery of trauma is discriminated against by being poorly taught if taught at all. We must be belligerent against such discrimination.

A letter and questionnaire was sent to the deans of seventy-nine medical schools in the United States and Canada.

1. What provision has been made for the teaching of traumatology in your school [other than the lectures covered by general surgery?]
2. Have you any affiliated hospital facilities for regular or special classes for teaching, demonstration and treatment of acute injuries?
3. Would it be possible to have a special course in traumatology for the senior medical students?
4. Could it be arranged in your affiliated hospitals to have special service assignment in the care of accidents and injuries for
   - A. Externe Service
   - B. Interne Service
   - C. Resident Service
5. How much time is given to traumatology?
   - A. In the general surgical course
   - B. In special lectures
   - C. In hospital service.

Thirty seven did not reply.

Twelve returned the questionnaire stating they were not permitted to answer unless it had been approved by the Executive Council of the Association of American Medical Schools. Twenty stated there was no time in the already crowded curriculum and there was no service in their hospitals for the care of accident patients. Two stated they believed that trauma was adequately covered by the surgical specialties and no special instruction and training was warranted. Eight medical schools fortunate in having affiliated hospitals with a large number of accident cases already have or are developing courses and services covering all phases of trauma.

TABLE 1
RESULTS OF ACCIDENTS OCCURRING IN FOUR MAJOR CATEGORIES AS TO ORIGIN OF ACCIDENT 1946

Origin of Accident	Result		
	Death	Disabling Injury	Permanent Impairment
Occupational industry	16,500	2,050,000	90,000
Farm	4,500	320,000	46,000
Transportation	35,000	1,200,000	100,000
Home	33,000	5,000,000	130,000
Total	89,000	8,570,000	366,000

This apparent disregard of the importance of traumatology is incomprehensible since casualties far out number all other conditions requiring professional attention and accounts for a great number of preventable disabilities and deformities, avoidable deaths and fabulous monetary and economic loss. Injuries however expertly treated are the chief cause of costly, frequently unwarranted, litigation which often brings discredit, not only to the doctor who treated the patient but also to the entire surgical and medical profession.

This Association is guilty of grave negligence in failing to compel due consideration for the teaching of traumatology in all our medical schools and their affiliated hospitals. We should demand competent continuous supervision of acute traumatic conditions in all municipal, county and regional hospitals. The management and treatment of acute traumatic conditions demands versatility and resourcefulness, a greater degree of skill, more meticulous technic, better judgment, instant and prompt decisions to care for many types of injuries than that required in elective surgery. This is all the more momentous since accidents occur anywhere always unexpectedly. Many with serious, complex or multiple injuries occur

under circumstances and conditions in which facilities for treatment are inadequate or entirely lacking and trained personnel are not readily available.

Of the total estimated deathsf rom accidents in 1946 accidents in industry account for about

TABLE II
MOTOR VEHICLE ACCIDENT DEATHS BY SIZE OF COMMUNITY IN WHICH ACCIDENT OCCURRED

Size in Community in Population	No. of Deaths	Per Cent of Deaths
Metropolitan (50,000 or over)	7,250	21.5
Urban (2,500 to 50,000)	5,250	15.6
Rural (less than 2,500)	21,200	62.9
Total	33,700	100.0

16.5 per cent, in farm occupation 4.5 per cent, in transportation 35 per cent and in the home 33 per cent. Accidents in other settings account for about 11 per cent of the total.

The cost of accidents can be only roughly approximated, no information is available on the cost of occupational accidents on the farm. The estimated cost of injury is as follows:

Industry	$2,400,000,000
Motor vehicle	2,200,000,000
Home	700,000,000
Total	$5,300,000,000

If these costs are recomputed in terms of deaths in these categories, one can estimate that all accidents cost about $6,300,000,000.

Thus almost two-thirds of deaths from motor vehicle accidents occurred in areas where there were no facilities for definitive care of injuries. Only one-fifth of deaths from motor vehicle accidents occur in communities where there is likely to be facilities to deal properly with all types of injuries.

Deaths from accidents occurring in rural areas constitute about 35 per cent of deaths from all accidental deaths. Teachers and surgeons working in the ideal environment of metropolitan or urban medical centers cannot appreciate the handicaps and limitations besetting those working in rural and remote areas.

We must develop plans to supplement the deficiencies in instruction in medical schools, the lack of training experience in teaching hospitals and dispensaries, encourage the building and equipping of district, regional and community hospitals and supplying regional communities with readily available competent consultation service.

TABLE III
DEATHS FROM ACCIDENTS OCCURRING IN RURAL AREAS

Type of Accident	No. of Deaths	Per Cent of Deaths
Motor vehicle	21,200	59.4
Home	10,000	28.0
Occupational (farm)	4,500	12.6
Total	35,700	100.0

We are not interested in restricting the surgery of traumatic conditions to a few highly trained eminently qualified specialists. The surgery of traumatic conditions from the very beginning has been and will always be basic surgery. We are deeply concerned in broadening the field, stimulating interest, increasing the efficiency of all medical men from the metropolitan medical centers to the most remote and isolated areas of our country. This Association with propriety could publicize these meetings and welcome the attendance of the general profession thereby widely disseminating the benefits of these programs. Alerting the teacher and elevating the teaching standards is of vital importance; no less important is improving the care and treatment of those sustaining injuries not only in the metropolitan and urban centers but also those injured in accidents at the cross roads, on the highways and byways, in the homes, on the farm and ranches and in transportation by rail, auto or air throughout our land.

When complete attention cannot be given, it is more important and far better to know how and what to do to shield the wound and protect the patient without adding to the damage already sustained. The temptation to attempt too much is very great. Where but in the receiving and accident wards are students taught there are limitations beyond which one may not safely go, and are made to appreciate the invaluable limb and life saving restraint and self control imposed by these limitations.

There is a vast difference between good first aid on the spot, efficient emergency care which

is usually given by the local general practitioner and early competent definitive treatment rendered under more favorable circumstances. Each is absolutely essential to the best service of the injured. Only a small fraction of injuries if properly handled from their inception will require hospitalization. Cnly by competent application of the principles of care of injuries with due regard for details in the treatment of small wounds can complications be avoided. "Trifles make perfection. Perfection is no trifle."

In many casualties the injuries are multiple although only one, the most evident, receives attention. The others, frequently the more serious, are overlooked in a hasty or too casual examination. Where are students to be taught how to make a careful, gentle yet thorough examination of the seriously injured. Knowing how to transport a seriously injured person promptly, speedily, gently and safely to the nearest place where facilities and competent personnel are available for more efficient treatment without compounding injuries or adding to the shock, is often the best service that can be rendered. It may be life saving. Do medical schools give instruction in the very important phase of the management of trauma?

Since first aid is so important and proper transportation often demanded is so vital, a thorough comprehensive course in first aid should be given to every class in every medical school. These students when graduated will be qualified teachers of first aid and can give competent instruction to classes in high school and parochial schools, colleges, in every industry employing large numbers of workers, public utilities, mines, police and fire departments and transportation companies in the service clubs and other organizations. Teach first aid not as a hobby, not as a psychic sedative for distraught nerves during periods of national emotional distress but as a serious, continuing professionally and supervised program for responsible laymen everywhere.

Large industries learned long ago that accident prevention, first aid and prompt efficient care of injured employees pays. Profiting by these experiences legislatures enforced installation of safety devices and the care of the injured in all industries large and small. Our Association should interest itself in directing, improving, if not actually participating in this movement of safety first.

Recently national legislation has been introduced to make this program part of the plan of compulsory health insurance. Unfortunately the general medical profession has not kept itself informed on this political trend. This Association should interest itself in the implications and inequities of current legislation. This is a must unless you want politically controlled, tax-burdened socialized medicine.

The tremendous number of accidents, the increase in gravity of injuries incident to our modern way of living, our prodigious industrialization, the mechanization of home, farm, ranch and city activities, the modernization and increase in speed of transportation obligates renewed attention upon the prevention of accidents, the protection of people and the more efficient care and prompt competent treatment of all types and degrees of injuries in order to better serve the public.

This compels the organization of an effective overall program of safety first; popularize first aid classes, demand greater consideration and stress in teaching fundamental principles of surgery and medicine in all medical schools, stress competent supervision of the training of students and residents in receiving and accident wards, make county, community and regional hospitals more accessible and provide qualified regional expert consultation service in order to avoid the appalling increase in casualties which are largely preventable, to reduce suffering, loss of time, disability, deformity and death.

We must be alert and become belligerently aggressive if we are to justify the function and purpose of our Organization. Our duty is clear, the task is great and the program formidable. With unity of purpose, we can accomplish great things for surgery and the better service for mankind.

Original Articles

TRAUMATIC RUPTURE OF THE GALLBLADDER AND LIVER

REPORT OF A CASE WITH GENERALIZED BILE PERITONITIS

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IN the absence of penetrating wounds of the abdomen, traumatic rupture of the gallbladder or liver is seen so infrequently that either condition is seldom suspected. When present, these conditions are sometimes masked by other more evident associated injuries. If diagnosis is not made, or at least suspected, the patient may succumb for want of proper surgery. The following case is reported with the hope of stimulating interest in these infrequent injuries and because no report of a similar case of rupture of both the gallbladder and liver resulting in generalized bile peritonitis can be found in an extensive search of the available literature.

CASE REPORT

M. W., 26173, a white male aged thirty, while intoxicated was riding in the front seat of a car being driven by another man who apparently was drunk also for it is said that they ran headlong into an embankment at a high rate of speed at about 1 A.M. on August 24, 1947. The patient was supposed to have been "thrown through the windshield." He was brought to the emergency room of the Baroness Erlanger Hospital at 2 A.M. and was treated by the house staff of the charity surgical service. He was bleeding profusely from many large lacerations of the face, forehead and scalp. His blood pressure was 140/100. Although drunk, he was conscious and complained of fullness of the bladder and an inability to void while his wounds were being sutured. He persisted in this complaint until surgery was interrupted and he was catheterized. Examination of this urine was negative. Suturing was resumed until he became pale, thirsty and complained of severe pain in his chest and lower abdomen and his systolic blood pressure fell to 102. He was given 500 cc. of citrated whole blood after which closure of his head wounds was completed.

The patient was put to bed at 3:30 A.M. His pulse was recorded at 100, blood pressure at 118/98, temperature 99°F. and leukocyte count 10,500. Wangensteen suction was instituted and 1,000 cc. of a 5 per cent glucose solution in normal saline was administered intravenously. This was ordered every eight hours. He was given 30,000 units of penicillin intramuscularly every three hours. He was ordered to have nothing by mouth but was found drinking the ice water out of his ice cap later in the morning.

X-ray films of his chest and abdomen taken on a portable machine were essentially negative. Because it was still suspected that he had a ruptured viscus, he was taken to the x-ray room and a roentgenogram of the abdomen with the patient in the upright position revealed no air under the diaphragm. After this no further mention was made on his chart of the possibility of such a rupture in spite of a rise in temperature and pulse, the development of colicy abdominal pain, generalized abdominal tenderness and rigidity, nausea, vomiting, distention and diarrhea.

When I first saw this patient sixty-six hours after admission, it was evident that he had a generalized peritonitis, most probably from a ruptured viscus, and he was immediately prepared for surgery. Operation was performed under spinal anesthesia. A right rectus incision was employed and the true nature of the rupture was guessed before the peritoneum was opened for it was stained a dark green. Upon entering the peritoneal cavity, thick, clear, green fluid gushed up into the incision. Approximately 3 pints were removed by suction. Exploration revealed every surface within the abdomen stained the same dark green. The gallbladder was found to be partially collapsed and bile was oozing through a diagonal tear which involved approximately two-thirds of its circumference, extending through the gallbladder bed and continuing upward as a vertical laceration of the liver through its anterior edge approximately 2 inches deep. Since it would have been very difficult to effect a leak-proof closure of the tear in both the liver and the gallbladder, it was considered best to remove the latter. This was accomplished from

below up, suturing the bed as the gallbladder was removed. The wound in the liver was easily closed with only two deep mattress sutures of chromic catgut using an atraumatic needle. The appendix appeared in the incision as closure was commenced so it, too, was removed. Five Gm. of sulfanilamide crystals were sprinkled into the abdominal cavity, a cigarette drain was left in the gallbladder fossa and the abdomen was closed in layers.

Recovery was prompt. The patient, fully ambulatory, was discharged from the hospital on his eighth postoperative day, the drain was removed on the eleventh day after operation and he was dismissed on his sixteenth postoperative day. He was last seen four months later, at which time he was in good health and working hard.

RUPTURE OF THE LIVER

Although solid viscera are more frequently injured than hollow ones[92] and the liver is thought by some to be the most frequent solid viscus to be ruptured by external trauma,[25,26,49] this injury is still rarely encountered by the average surgeon. Traumatic rupture of the liver is seen most frequently in the accident rooms of large urban hospitals[87] where its incidence is about 1 in 1,500 cases.[87,92,102] There are only ten proven cases in the records of the Mayo Clinic[98] before 1939. The right lobe is much more frequently ruptured than the left.[7,62,91,102]

There are three types of traumatic rupture of the liver which can be classified as follows: (1) Rupture of the liver and capsule; (2) subcapsular rupture, either of hepatic tissue just beneath the capsule[79,80] or separation of Glissons' capsule from the liver;[66] (3) central rupture.[15,80,94,103] By far the vast majority of ruptures of the liver are of the first type.

Without penetrating wounds of the abdomen, traumatic rupture of the liver is caused almost entirely from blows upon the abdomen by blunt objects or by squeezing or crushing trauma. Tangenital force, carrying the organ beyond its limits of mobility, has been blamed for some lacerations of the liver, particularly the central ones.[98] Tortion, produced by rotating a child during delivery, is the cause of rupture of the liver which is occasionally seen in the newborn infant.[55,71]

Wright, Prigot and Hill describe four clinical types of cases of traumatic rupture of the liver: (1) Those with massive hemorrhage resulting in immediate or rapid death; (2) those with acute hemorrhage showing evidence of internal hemorrhage and shock; (3) those with repeated small hemorrhages who became intermittently worse or suddenly change into the acute type and finally (4) those with little or no hemorrhage who usually undergo spontaneous cure.

Since intra-abdominal hemorrhage is the most common and pronounced finding in cases of a ruptured liver, those who are not killed outright demonstrate the signs and symptoms of this bleeding, which include pain, weakness, pallor, restlessness, dyspnea, rapid pulse, fall in blood pressure, shifting dullness, subnormal temperature, anemia and leukocytosis.[7,52,101] The patient may go into shock at any time. Nausea and vomiting are usually present. The vomitus may be bloody from hemorrhage through the biliary system.[40,102] If the patient survives a few days, a mild jaundice usually becomes manifest.[90] Abdominal tenderness and rigidity, more pronounced in the upper abdomen, is the rule. Right shoulder pain has been noted by several authors,[28,53,60] particularly when the dome of the right lobe of the liver is the site of the rupture. In some cases of subcapsular rupture the mass beneath the capsule has been palpated. Bradycardia has been observed[30,33,68,90] but most writers have not found it.

The diagnosis of a ruptured liver in the absence of penetrating wounds of the abdomen can be very difficult.[23] The most helpful findings are those of intra-abdominal hemorrhage with localization of the pain and tenderness to the right upper quadrant. If right shoulder pain is present, this is an added clue. The symptoms of rupture of the liver are almost indistinguishable from those seen in cases of rupture of the spleen. This makes little difference, however, for the indications for operation are the same in the two conditions. It is important to distinguish rupture of the liver from retroperitoneal hematoma for there is usually no indication for operation in the latter, yet the two conditions can easily mimic one another.

X-ray is of little value in the diagnosis of traumatic rupture of the liver despite its advocacy by Burke who uses thorotrast to visualize the outline of the liver in a four-hour diagnostic procedure. Following trauma to the abdomen, too much reliance should not be placed upon the absence of air under the diaphragm[95] for this merely rules out rupture of the gastrointestinal tract. It does not elimi-

nate the possibility of the presence of a rupture of either the liver or gallbladder.

Abdominal tap performed with a blunt spinal puncture needle in all four quadrants has been found to be very helpful in suspected cases of ruptured viscus.[63,102] This procedure is not without danger, however, as there have been fatalities reported from its use.[48] Peritoneoscopy has its proponents and opponents as has abdominal exploration through a tiny incision.

There is no agreement among surgeons on the indications for operation or on the optimal time for surgery.[64] It seems reasonable, however, to state that if the patient is in profound shock, it is wise to attempt to get him in a stronger condition by the use of transfusions, plasma, glucose and other antishock measures before operating. If no headway is made, surgery may have to be attempted anyway. On the other hand, if the patient is not in shock and symptoms point toward a cessation of bleeding, a conservative attitude may be taken and surgery postponed as long as the patient's condition progresses satisfactorily for spontaneous recovery from small ruptures of the liver definitely occur.

At operation the blood in the peritoneal cavity from a rupture of the liver should be removed and thrown away. Autotransfusion has been advocated in these conditions,[3,97,100] but it should not be performed because the presence of bile in the blood renders it toxic.[52,102] Death from anuria shortly after using such blood has been recorded.[1]

Many bizarre methods long since antiquated have been proposed to stop bleeding from the torn liver. They are too numerous to enumerate.[2,4,14,17,32,73,89,93] Despite popular belief to the contrary the best and most simple way to control hemorrhage from the liver is by simple and careful deep suturing, providing the laceration is accessible. If the laceration is too stellate or macerated to suture or it is inaccessible, a hot wet pack held in place under pressure for ten minutes or more has been successful in arresting hemorrhage from the liver.[52] The pack should be removed if possible before the abdomen is closed[70] because there are numerous complications reported from packing wounds of the liver. A coagulum contact technic using fibrin foam, oxidized cellulose gauze, or "gelfoam" has lately been used with favorable results in ruptures of the liver.[35,83] Use of this procedure replaces the need for packing with gauze. Any detached fragment of liver should be removed because of the toxicity resulting from necrotic liver tissue remaining in the abdominal cavity.[6,36] For the same reason all badly traumatized liver tissue should be excised. Branch resected approximately one-half of the liver that was badly torn in a child seven years of age without technical or clinical difficulty. Most surgeons are in accord that patients with a ruptured liver should have drainage for a few days, preferably with soft rubber tissue or a small cigarette drain. Sulfonamides, penicillin and streptomycin should be employed whenever indicated. A high carbohydrate intake has been found helpful in the convalescence of these patients.[5,53]

Traumatic rupture of the liver is a dangerous injury. All patients with massive hemorrhage die usually before surgery can be attempted. All of those with acute hemorrhage die if they are not given the benefit of surgery. The mortality in the group operated upon has been variously reported from 28[42] to 60 per cent,[102] a majority of observers reporting the mortality at approximately 40 per cent.[46,49,66]

Recently much has been written about the association of rupture of the liver with the hepatorenal syndrome, or "liver death," but Wright and his co-workers did not observe this in any of their thirty-two consecutive cases.

RUPTURE OF THE GALLBLADDER

Without penetrating wounds, rupture of an otherwise normal gallbladder is of very rare occurrence.[51,86] Reports of only thirty-three proven cases can be found in the literature,[9,18,29,31,41,48,61,65,76,78,81,85,86,94] most of these were collected by Lewerenz in 1903, Richetts in 1905 and Norgore 1946.

As with rupture of the liver the predominating force responsible for subcutaneous rupture of the gallbladder is a blow to the abdominal wall by a blunt object or a squeezing or crushing type of trauma. It must be extremely difficult to actually tear the gallbladder from external trauma unless it is distended at the time of injury[65] or the cystic duct is occluded by a stone[85] because this organ is so well protected beneath the liver. It is remarkable that none of the reported cases with a tear in the gallbladder had a simultaneous rupture of the liver.

There are two types of injuries of the gallbladder noted in the reported cases: (1) actual

laceration of the gallbladder wall and (2) "rupture" of the gallbladder from the liver. In this latter type the gallbladder is pulled away from its bed and hangs either by its neck[61,81] or is torn entirely from the liver and lies free in the abdominal cavity which Brown so aptly termed "traumatic cholecystectomy."

When the gallbladder is lacerated, bile escapes into the abdominal cavity and bile peritonitis ensues.[72,84] This is not such a catastrophe if it becomes walled off for localized pockets of bile can be well tolerated,[27,65] but if it becomes generalized, which is most frequently the case, it kills rapidly.[13,19,24,54,65,88] The introduction of even small amounts of bile into the peritoneal cavity will kill dogs and guinea pigs within twenty-four hours.[43]

The exact nature of the harmful effect of intraperitoneal bile is controversial. McLaughlin and others[38,43,44,58,96] believe it is due to the toxicity of its components, especially the bile salts and acids. On the other hand, it has been shown that following the introduction of bile into the abdominal cavity, ascites rapidly develops hence there is fluid loss from the circulation, sometimes enough to produce severe shock. Many believe this is the lethal factor in bile peritonitis.[38,58,60] Bacterial growth in the bile frequently complicates the chemical peritonitis and shock and this is thought by Mentzler and others[54,75,94] to be the chief cause of death in bile peritonitis. There is still another group[57,74,94] who have noticed a brownish fibrinous exudate covering the peritoneum of those in late stages of bile peritonitis. These observers believe death comes from blockage of the lymphatics by this exudate. It seems reasonable to assume that any combination or all of these factors may come into play in the fatal cases. But whatever causes death bile peritonitis carries with it a high mortality. It ranges between 50 and 75 per cent.[54]

The diagnosis of traumatic rupture of the gallbladder is more difficult to make than the diagnosis of rupture of the liver for the symptoms of bile peritonitis develop more slowly than the symptoms of intra-abdominal hemorrhage and shock is not as likely to appear as suddenly. The gravity of the situation, therefore, is more apt to go unrecognized in patients with traumatic rupture of the gallbladder, particularly when these patients are first seen. Bradycardia has been noted[90] but this is the exception, not the rule. Mild jaundice from absorption of the bile from the peritoneum is sometimes perceptible within a few hours after the accident. Abdominal puncture confirms the diagnosis if bile or bile-stained fluid is obtained by this procedure.

The treatment of traumatic rupture of the gallbladder is definitely operative and consists of either suturing the tear or removing the gallbladder. These procedures are usually easy because the organ is not diseased.

The year 1898 marks the turning point in the prognosis of patients with traumatic rupture of the gallbladder. Before that date not a proven patient that suffered this injury recovered, either with or without operation.[1] In that year also was recorded the last death following operation. Every reported patient operated upon since has recovered.

SUMMARY

1. A case is reported of a patient with rupture of the gallbladder and liver without a penetrating wound of the abdomen who rapidly developed generalized bile peritonitis. This patient promptly recovered after the diagnosis was made and proper surgery instituted.

2. A review of the available literature reveals no previously reported similar case.

3. Rupture of the liver is a rare and dangerous injury. There are three clinical types. Symptomatology, diagnosis, treatment and prognosis are different in each type. A discussion of the problem is presented.

4. Traumatic rupture of the gallbladder is a very rare injury. Reports of only thirty-three proven cases can be found. This injury is usually characterized by development of a generalized bile peritonitis which is fatal unless it is remedied by surgery hence making the diagnosis becomes paramount.

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PERFORATION OF THE SMALL INTESTINE FROM NON-PENETRATING ABDOMINAL TRAUMA

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PERFORATION of the small intestine as a result of trauma without penetration of the abdominal parietes is an unusual lesion but one which is apt to result in disaster if not diagnosed early and operated upon promptly. A recent case, fortunately with favorable outcome, in which perforation was not suspected for twenty-two hours prompted this search for similar lesions in the records of nearby hospitals and a review of the literature on the subject.

In 1935 Counseller and McCormack[8] reported on 1,313 cases which had been published up to that time. In their series the total mortality was 73.4 per cent and the operative mortality in the 887 patients explored was 60.7 per cent. Poer and Woliver[27] in 1942 added 199 cases by presenting 163 cases which had been reported subsequent to Counseller's series and thirty-six cases which they had gathered from the city hospitals of Atlanta and Cincinnati. The total mortality in this combined group was 61.2 per cent and the operative mortality 52.6 per cent in 158 patients explored. In both the Counseller and Poer reports perforations of the stomach and the colon were included but the number of these was so small as not to affect the statistical results materially.

This paper is restricted to perforations of the small intestine due exclusively to non-penetrating external abdominal trauma. The stomach and colon are excluded from consideration as are perforations due to muscle strain, water blast and pre-existing diseases of the small bowel. Congenital anomalies such as diverticula and hernias are included if perforation resulted directly from non-penetrating trauma. Apart from one or two references in the Russian, Turkish and Scandinavian literature, which were unavailable, seventy cases of this nature have been published from Poer's report[27] to July 1947. These seventy plus the eleven herewith presented for the first time form the basis of the present study.

CASE REPORTS

CASE I. No. 230198, C. B., (N. Y. Hospital). At 6:30 A.M. on March 29, 1939, a fifty-six year old colored man tripped and fell on the street. He worked as a porter, the rest of that day and most of the next in spite of abdominal pain and vomiting. He was admitted to the hospital sixty hours after his fall in a critically ill condition, with a diagnosis of generalized peritonitis. His temperature was 39°C., blood pressure 95/75, pulse 100, white blood count 17,200; urinalysis was negative. Roentgenograms of the abdomen with the patient upright revealed no air beneath the diaphragm.

He was given adequate supportive therapy and within two hours of admission an exploratory laparotomy was performed by Dr. John Eckel. The abdomen was full of pus and undigested string beans. There was a gross, advanced, generalized peritonitis. A freely leaking 1.5 cm. perforation of the antimesenteric border of the ileum was found 3 feet from the ileocecal valve. A soft rubber tube was sewed into this perforation and brought out as a Witzel enterostomy. Gross débris was removed from the abdominal cavity; 4 Gm. of sulfanilamide powder were sprinkled about the site of perforation and the abdomen was drained through a lateral muscle-splitting incision. The patient died twelve hours after operation and postmortem examination confirmed the operative findings.

CASE II. No. 458359, M. S., (N. Y. Hospital). A forty-seven year old white male fell 20 feet into an open pit on October 9, 1946. He lost consciousness for ten minutes and was admitted to the hospital soon thereafter, still semi-comatose. His complaints were of diffuse abdominal pain and pain in the right shoulder.

Examination revealed the temperature to be 37.6°C., pulse 105, respirations 20, blood pressure 110/60. The patient was in acute pain, retching and vomiting. There were tenderness, spasm and rebound tenderness most marked in the left upper quadrant. The white blood count was 18,200 with 88 per cent polymorphonuclears. Urinalysis was negative except for a rare red blood cell and one to three white blood cells. Roentgenograms of the abdomen with the patient upright revealed no air beneath the diaphragm.

Supportive therapy was given and the patient observed, but as all signs and symptoms steadily increased an exploratory laparotomy was performed six hours after the injury by Dr. William Barnes. Fifteen hundred cc. of fluid and clotted blood were found in the peritoneum. There was a 1 cm. perforation in the antimesenteric border of the proximal ileum, with a rent in the mesentery which included a large ruptured artery. The artery was suture ligated and the perforation and tear closed with fine interrupted silk. No sulfonamides were placed in the peritoneal cavity and no drainage was instituted. Postoperative distention was controlled with Wangensteen suction, and the patient was discharged well on the fourteenth postoperative day. He was seen two months following operation at which time he was well and the gastrointestinal roentgenographic series taken then was negative.

Case III. No. 423239, G. H., (N. Y. Hospital). On April 19, 1946, a piece of wood flew from a saw and struck this fifty year old white male in the right lower quadrant. He was knocked unconscious for a few minutes and when he came to had severe cramp-like pain in the right lower quadrant and right groin. He complained of frequency and slight dysuria. About twenty-four hours after injury he began to vomit and the pain steadily became worse. He was finally admitted to the hospital four days following injury.

At examination a lean white male, age fifty, lay quietly in bed with his knees slightly flexed. His temperature was 37°C., pulse 106, respirations 20, blood pressure 125/75. Movements of the trunk were painful. Ecchymosis was seen in the right lower quadrant. Tenderness and spasm were present; rebound tenderness in the right lower quadrant was marked. The lower abdomen was distended and tympanitic. The white blood count was 6,300 with 83 per cent polymorphonuclears. The urine contained albumin 3 plus and was loaded with casts. Roentgenograms with the patient in the upright position revealed free air beneath both leaves of the diaphragm and distended loops of small bowel with fluid levels.

Promptly after admission an exploratory laparotomy was performed by Dr. Guy Maynard. An abscess pocket containing pus and feces was found in the rectal cul-de-sac, walled off by reddened loops of small bowel which were matted together with fibrin. There was 1.5 cm. perforation in the terminal portion of the ileum. It was closed with interrupted sutures of fine silk. Further exploration was not carried out because of the abscess. Four Gm. of sulfanilamide powder were sprinkled in the abdomen. Closure was effected with catgut in layers without drainage. The postoperative course was afebrile. The patient was discharged well on the twenty-ninth postoperative day. On follow-up examination at nineteen months the patient complained of an occasional postprandial feeling of upper abdominal fullness. Examination was negative as was a gastrointestinal roentgenographic series taken at the same time.

Case IV. No. 95394, J. P., (N. Y. City Hospital). While working, a twenty-four year old window washer fell two stories onto a fire escape and struck his abdomen against a large spike. He did not lose consciousness and he was brought to the hospital a short time afterward.

The patient was suffering from acute abdominal pain. There were generalized abdominal tenderness, spasm and rebound, greatest below the umbilicus. There was a superficial laceration of the penis. The patient was not in shock. A roentgenogram of the abdomen with the patient upright revealed air beneath the diaphragm.

A diagnosis of ruptured viscus was made and an exploratory laparotomy was performed by Dr. Roland Hipsley six hours after injury. A complete transverse rupture of the jejunum at the ligament of Treitz was found. The proximal end of the jejunum was inverted with a double layer of sutures and the distal loop of jejunum was brought out through the lower end of the incision. During the operative procedure the patient went into shock but was returned to the ward in fair condition. His postoperative course was stormy and nine days later at a subsequent operation 1 foot of gangrenous jejunum was resected and a pelvic abscess was drained. In spite of this he steadily became weaker and died on the twelfth postoperative day.

Case V. No. 147098, J. C., (N. Y. City Hospital). A forty-three year old white male, who had been drinking heavily, fell on his abdomen at 1:30 A.M. on January 1, 1947. He was admitted to the hospital by ambulance about one hour later in a semi-comatose condition. There was a strong odor of alcohol on the patient's breath. There were generalized tenderness, spasm and rebound in the abdomen, greatest in the right lower quadrant. A roentgenogram of the abdomen with the patient erect revealed air beneath the diaphragm.

Thirteen hours after injury an exploratory laparotomy was performed by Dr. H. D. Stein. A 2 cm. perforation of the antimesenteric border of the ileum 9 inches from the ileocecal valve was found. This was closed with a simple inverting stitch and the abdomen was closed without drainage. The postoperative course was uneventful apart from a mild superficial wound infection. The patient was discharged well on January 25 1947. He was readmitted on September 12, 1947, at which time an incisional hernia was repaired, and he was discharged well on September 25th.

Case VI. No. 21722, J. S., (Grasslands Hospital). A forty-seven year old laborer was struck

in the right lower quadrant with the end of a crowbar while he was trying to move a heavy stone on May 20, 1935. He did not fall but had immediate abdominal pain and was brought to the hospital two hours later.

The patient was in acute abdominal distress, perspiring profusely, with agonized facies. His temperature was 98°F., pulse 70, respirations 20, blood pressure 120/65. Pain, tenderness and spasm were marked in both lower abdominal quadrants, greatest in the right lower quadrant. There was no rebound tenderness. The white blood count was 7,000 with 70 per cent polymorphonuclears. No x-ray was taken.

The patient vomited once after admission. He was kept under observation about eighteen hours and maintained a good pulse and blood pressure until the next morning when he went into shock rather suddenly. Exploratory laparotomy twenty-one and one-half hours after injury by Dr. Wilshusen revealed a 1.5 cm. perforation of the ileum at its juncture with the jejunum and generalized peritonitis. The perforation was closed and the abdomen was drained. The patient died of peritonitis and shock fifteen hours after operation.

Case VII. No. 62782, M. M., (Grasslands Hospital). While riding a bicycle, a thirteen year old white male struck a stone wall on May 31, 1935. He did not lose consciousness and was admitted to the hospital within ten minutes of injury.

The patient was perspiring but not in shock. His temperature was 100°F., pulse 90, respirations 20, blood pressure 120/80. There was moderate tenderness of the entire abdomen and some voluntary spasm but no rebound tenderness.

The patient vomited several times and his abdominal signs increased during a few hours of observation. The white blood count was 18,000 with 85 per cent polymorphonuclears. No x-ray was taken. An exploratory laparotomy eight and one-half hours after injury by Dr. C. T. Smith revealed a rupture of the jejunum about 1.5 cm. in diameter. The perforation was closed and the abdomen drained. The patient had an uneventful recovery.

Case VIII. No. 82715, E. R., (Grasslands Hospital). While working on June 3, 1943, a sixty-seven year old hospital porter was caught between two loaded stretchers and received a sharp blow across the lower abdomen. He complained immediately of severe, constant abdominal pain, weakness, dizziness and nausea. He was admitted to the hospital one hour after injury.

Examination revealed an elderly white male in acute distress. His temperature was 97.8°F., pulse 90, respirations 22, blood pressure 176/98. He vomited once during examination. There were generalized abdominal pain, tenderness, spasm and rebound, greatest in the right lower and upper quadrants. Small reducible right and left inguinal hernias were present. The psoas sign was positive. The white blood count was 5,000 with 66 per cent polymorphonuclears. Urinalysis was negative except for a trace of albumin. X-ray of the abdomen with the patient erect failed to show air beneath the diaphragm.

The patient maintained normal temperature, pulse, respirations and blood pressure during the first seven hours of observation although he vomited once more, this time 300 cc. of chocolate-colored fluid with a small amount of bright blood. During the night, however, his condition rapidly deteriorated and in the morning it was believed that exploration would be fatal. The temperature had risen to 105°F. and the blood pressure had dropped to 56/40. He died twenty-seven and one-half hours after injury. Autopsy revealed a 1 cm. perforation of the antimesenteric border of the ileum at its junction with the jejunum. The perforated loop of bowel lay close to the right internal inguinal ring. An indirect inguinal hernial sac was found on the right side. There was generalized peritonitis.

Case IX. No. 80505, E. T., (Mt. Vernon Hospital). A twenty-six year old carpenter was struck forcibly in the abdomen below the umbilicus with the edge of a large piece of wood. He vomited once and complained of abdominal pain and nausea.

His temperature was 97.8°F., pulse 88, respirations 20, blood pressure 140/80. There were generalized abdominal tenderness, spasm and rebound tenderness, especially below and to the right of the umbilicus.

Operation performed by Dr. Essrig on June 12, 1946, revealed a complete rupture of the jejunum 6 inches from the ligament of Treitz. The bowel ends were inverted and a side-to-side anastomosis was effected. The abdomen was drained. Time lapse from injury to operation was not recorded. Roentgenograms to show air beneath the diaphragm were not taken. The patient was discharged well four weeks after operation.

Case X. No. 115642, W. D., (Mt. Vernon Hospital). A forty-one year old man was struck forcibly in the lower abdomen by a piece of wood which was kicked back by a circular saw. He collapsed and was brought promptly to the hospital. He vomited once.

His temperature was 101.4°F., pulse 130, respirations 26, blood pressure 122/86. There was slight ecchymosis of the skin over the lower abdomen. The abdomen was soft and not tender on admission but pain, spasm and tenderness developed later.

Operation performed about thirty-six hours after injury by Dr. Restin disclosed a ½ inch perforation of the jejunum 16 inches from the ligament of

Treitz and generalized peritonitis. The perforation was closed and the abdomen drained. The patient expired shortly after operation.

CASE XI. No. 66749, J. F., (Northern Westchester Community Hospital). A seventeen year old high school student was first seen by Dr. Donald W. Richie at his office in Croton Falls, New York, at 7 P.M. on October 10, 1947. Two hours earlier while playing football and blocking another player he had been struck hard on his left side and had fallen to the ground, striking his head. He was groggy but not unconscious and was able to walk off the field. When first seen his only complaints were those of headache and pain in the left side.

There was moderate tenderness in the left flank but not in the abdomen and the patient was not in shock. However, he was unable to void. During the trip to the hospital he was nauseated and vomited several times. Examination performed shortly after the patient's arrival at the hospital revealed moderate generalized abdominal pain, tenderness and spasm, with rebound tenderness, especially on the left side. Peristalsis was active. Examination of the central nervous system was negative. His blood pressure was 120/70, pulse 90, respirations 20.

At 9 P.M. patient was suddenly seized with excruciating abdominal pain. He voided a few minutes later with a marked decrease in pain. The laboratory findings at this time were as follows: Blood count: hemoglobin 108 per cent; red blood cells 4,880,000; white blood cells 18,700 with 76 per cent polymorphonuclears. Urine: 1.018; albumin 3 plus; sugar negative; microscopic: a few hyaline and many granular casts with 3 to 4 red blood cells per high power field. Roentgenographic studies of the abdomen, in both the supine and erect positions, revealed small bowel distention but no free air beneath the diaphragm.

At 7:30 A.M. the next day the abdominal pain and tenderness had subsided a considerable amount. There was some abdominal rigidity which was considered to be mostly voluntary. The white blood cells at this time numbered 21,500 with 90 per cent polymorphonuclears. In view of the patient's clinical improvement observation was continued.

At 3 P.M. on the same day the patient was seen in consultation. For the past three hours the pain, tenderness and spasm had increased. An exploratory laparotomy was therefore performed by me twenty-two hours after injury. A left upper rectus muscle splitting incision was made. The abdomen was full of bile-stained, cloudy fluid. The small intestines were matted together with fresh adhesions and covered with a fibrinous exudate. A 1 cm. perforation of the antimesenteric border of the jejunum was found 18 inches from the ligament of Treitz. Mucosa pouted through the perforation from which clear bile-stained fluid still leaked. The hole was closed with a double layer of intestinal suture. Fluid was aspirated from the abdomen and a thorough exploration was performed, with no further evidence of injury. A culture of the abdominal fluid showed no growth in forty-eight hours. The abdomen was closed in layers with catgut. No sulfonamides were placed in the peritoneum nor was the abdomen drained. The postoperative course was entirely uneventful. The patient was out of bed daily from the first postoperative day. He was discharged on the tenth postoperative day free of symptoms.

Incidence. Among 40,000 admissions to the surgical service at St. Luke's Hospital, New York City, and 20,000 similar admissions to the White Plains (N. Y.) Hospital during the past decade no instance of non-penetrating abdominal trauma causing a perforation of the small intestine is recorded. (Table I.) At Grasslands (N. Y.) Hospital three cases were encountered among 20,000 surgical admissions, at Mt. Vernon (N. Y.) Hospital two among 20,000, at New York Hospital three among 60,000 and at the New York City Hospital two among 20,000. Thus, in a survey of six metropolitan and suburban hospitals over a ten to fourteen-year period this lesion was encountered only once in every 10,000 to 20,000 admissions to the general surgical service, including the surgical specialties. Actually the incidence was probably much higher due to the difficulty of tracing such cases under the record systems used.

Age. In this series of eighty-one cases mortality seemed in no way related to age of the patient. Ages ranged from four to seventy-six years. The second, fourth and fifth decades were most frequently represented, accounting for two-thirds of the cases in which the age was stated.

Trauma. The main categories of trauma are listed in Table II. The type of violence which caused the perforation was interesting in several respects. Traffic injuries were the most frequent and included auto accidents of all kinds. Blunt blows were inflicted by iron bars, posts, chair legs and blocks of wood thrown by saws. Handles of cycles, wheelbarrows, shovels and stretchers caused injury when the patient was suddenly thrown violently against them. Of the four football cases one was due to a direct kick, another to a kicked ball, another to a tackle and the fourth

to an unknown trauma. It is noteworthy that in two cases the bowel was perforated during prolonged attempts to reduce an inguinal hernia in each instance by the patient himself. No direct relation could be found between trauma and mortality except that of the seven patients with severe multiple injuries, six of whom died, three without operation.

TABLE I
INCIDENCE OF SMALL INTESTINAL PERFORATION FROM NON-PENETRATING ABDOMINAL TRAUMA

Hospital	Years Covered	Approximate No. Surgical Admissions	No. Such Perforations Recorded
Grasslands	13 (1935–1947)	20,000	3
Mount Vernon	10 (1937–1946)	20,000	2
New York	14 (1933–1946)	60,000	3
New York City	12 (1936–1947)	20,000	2
St. Luke's (N.Y.)	11 (1936–1946)	40,000	0
White Plains	10 (1937–1946)	20,000	0
Total		180,000	10

Sites of Bowel Injury. Table III shows the frequency with which the various segments of small intestine were involved, the specified sites of perforation or tear and the relative mortality. The jejunum and ileum were about equally represented (thirty-eight and thirty-four cases, respectively). In only five cases was the duodenum injured. This low incidence of duodenal lesions may be due to deflection of the blow by the lower edge of the thoracic cage and perhaps some protection from the overlying transverse colon which has a redundant mesentery.

TABLE II
TYPES OF TRAUMA

Types	No. Cases
Traffic (automobile accidents)	24
Blunt blow (wood, post, bar, etc.)	21
Fall	11
Handles (cycle, barrow, shovel, etc.)	10
Kick	8
Football	4
Crush	2
Unknown	1

It is hardly surprising to find that in 82.2 per cent of all cases in which the tear was accurately localized (fifty-one of sixty-two cases) the lesion occurred at or close to a place where the bowel was firmly fixed to the parietes. In 86.6 per cent of thirty jejunal cases the perforation occurred within 2 feet of the ligament of Treitz while in 74 per cent of twenty-seven ileal cases it was located within 3 feet of the ileocecal valve. This has been pointed out by others as an important mechanical factor in the production of bowel tears. In effect, the firmly anchored bowel is incapable of eluding a violent blow directed at it.

TABLE III
SITE OF BOWEL INJURY

Site	No. Cases	No. Deaths	Mortality Per Cent
Jejunum	38	11	29.0
2 feet or less from ligament of Treitz	26	7	27.0
More than 2 feet from ligament of Treitz	4	1	
Not stated	8	3	
Ileum	34	14	41.2
3 feet or less from ileocecal valve	20	10	50.0
More than 3 feet from ileocecal valve	7	3	
Not stated	7	1	
Duodenum	5	2	
1st portion	1	1	
2nd portion	1		
3rd portion	1		
Not stated	2	1	
"Small bowel" (no site stated)	4	1	

It has been stated that the mesenteric border of the bowel is most frequently torn.[31] In this series, however, cases were about equally divided as follows: antimesenteric border nineteen cases, mesenteric border fourteen cases, complete severance four cases. In forty-four cases the border was not specified.

As will be seen in Table III, the mortality rate was definitely higher in the ileal than in the jejunal perforations, rising from 27.0 per cent for lesions of the upper jejunum to 50 per cent for those of the terminal ileum.

Size and Number of Perforations. The size of the bowel tear in these cases is analyzed in Table IV; 61 per cent (forty-two cases) were 1.5 cm. or less in diameter while 39 per cent (twenty-seven cases) were of larger diameter. Of the latter, three involved half the bowel circumference, two three-quarters of the bowel and in four cases the bowel was completely severed. The mortality rate was approximately the same in both the small and the large tears except that two of the four patients in whom the bowel was torn completely across died. In each of four patients multiple perforations (two or three in number) of the ileum were found within 2 feet of the ileocecal valve. Two of these patients recovered and two died.

TABLE IV
SIZE OF TEAR

Size	No. Cases	No. Deaths	Mortality Per Cent
1.5 cm. or less (including so-called "small" tears)	42	16	38.1
Over 1.5 cm. (including so-called "large" tears)	18	6	33.3
One-half of circumference torn	3	0	
Three-quarters of circumference torn	2	1	
Bowel completely severed	4	2	
Not stated	12	3	

Roentgen Evidence of Air beneath Diaphragm. In thirty-nine cases roentgenograms were taken of the erect patient preoperatively to demonstrate air beneath the diaphragm. Air was revealed in sixteen of these cases, but in the remaining twenty-three no air was seen. (Table V.) Only five of nine patients with tears known to be more than 1.5 cm. in diameter showed air beneath the diaphragm by roentgenogram of the erect patient, and in only eight of twenty-three patients with perforations reported as 1.5 cm. or less in diameter was air seen. No free air in the peritoneal cavity could be demonstrated roentgenologically in one case twelve hours after injury although the bowel had been torn half-way through. Another patient had no air beneath the diaphragm as demonstrated by roentgenogram twenty-four hours following a rupture which involved three-quarters of the bowel's circumference.

Roentgen examination is an important part of the diagnostic survey for when it is positive much valuable time may be saved, and it should be performed whenever possible. At the same time one must be very careful in evaluating this diagnostic aid and not allow himself to be lulled into a false sense of security when no free air is revealed. In considerably less than half of all perforations of the small bowel may the roentgenogram be expected to show air under the diaphragm.

TABLE V
ROENTGEN EXAMINATION FOR AIR BENEATH THE DIAPHRAGM

Size of Perforation	Air Shown	Air not Shown	Total Cases	Percentage of Cases in Which Air Was Shown
Large tears (more than 1.5 cm.)	5	4	9	44.4
Small tears (1.5 cm. or less)	8	15	23	34.8
Size of tear not stated	3	4	7	
Total Cases	16	23	39	41.0

TABLE VI
TIME LAPSE FROM INJURY TO OPERATION

Time	Total Cases	Deaths	Mortality Per Cent
10 hours or less	26	5	19.2
12 hours or more	37	13	35.1
Time not stated	12	4	
No operation	6	6	100.
Totals	81	28	34.5

Time Lapse from Injury to Operation. That the passage of time following perforation of a hollow viscus until operation is performed has a definite and vital bearing upon the patient's chances of recovery is well known. Six hours is usually taken as the longest period of delay for observation permissible when this condition is suspected. By that time a decision

should be made in most cases, for or against operative intervention.

The effect of delayed operative intervention in this series is shown in Table VI. Those patients who were operated upon twelve hours or more after injury had a mortality rate (35.1 per cent), nearly double that of the cases done within the first ten hours (19.2 per cent). Two patients, however, were operated upon as late as ninety-six hours, with recovery in each instance.

Mortality. Twenty-eight of these eighty-one patients died, a total mortality of 34.5 per cent; twenty-two of the seventy-five who were explored died, an operative mortality of 29.3 per cent. All six died who were not subjected to operation due to critical condition from multiple injuries.

Table VII sets forth the mortality rates in this and other series. It is not a true comparison for the other authors included perforations of the stomach and colon while the present series is restricted to perforations of the small intestine only. However, since in only 10 per cent of all cases[8] are the stomach and colon involved, it is believed that the figures accurately reflect a trend toward lower mortality rates in recent years. This should be so in view of the advances which have been made in the use of antibiotics, plasma and blood.

The mortality rates for this lesion are still too high. Patients continue to die because the possibility of perforation is not seriously considered or, having been considered, is discarded when the roentgenogram fails to show air beneath the diaphragm. Too much time is spent in wishful observation. In earlier diagnosis and surgical intervention lies our only hope of saving more lives.

TABLE VII
MORTALITY RATES

Series	Total Cases	Total Deaths	Total Mortality Per Cent	Patients Operated	Patients Died after Operation	Operative Mortality Per Cent
Counseller and McCormack (1935)	1313	965	73.4	887	539	60.7
Poer and Woliver (1942)	199	122	61.2	158	81	52.6
Author's (1948)	81	28	34.5	75	22	29.3

SUMMARY

1. Eleven hitherto unreported cases of perforation of the small intestine from trauma which did not penetrate the abdominal wall are presented. An analysis is made of these and of seventy additional case reports published since the medical literature on the subject was last brought up-to-date ten years ago.

2. In six New York City and suburban hospitals a non-penetrating traumatic perforation was encountered only once in every 10,000 or 20,000 surgical admissions. On the other hand two cases were seen in one of these hospitals within a six-month period.

3. In most cases the injury was the result of a sudden, severe and unexpected blow to the abdomen by some blunt object. However, on two occasions it was caused by vigorous efforts on the part of a patient to reduce his own hernia.

4. Eighty-two and two-tenths per cent of perforations in this series occurred in or not far from a relatively fixed portion of the bowel.

5. The majority of tears were 1.5 cm. or less in diameter but there was little correlation between the size of the perforation and the severity of symptoms produced.

6. Roentgen examination of the erect patient failed to show air beneath the diaphragm in 59 per cent of cases in which perforation was proven by operation or postmortem.

7. The total mortality in this series of eighty-one cases was 34.5 per cent and the operative mortality 29.3 per cent.

8. Delay in operation was the most important single factor in causing death. After the first twelve hours following injury the mortality rate doubled.

CONCLUSIONS

Perforation of a hollow viscus must be suspected when there is persistent abdominal pain, spasm and tenderness, with or without nausea and vomiting, subsequent to severe trauma to the abdomen. If these signs persist for six hours,

exploratory celiotomy should be performed forthwith, regardless of failure to find free air in the peritoneum by roentgenography. Under such circumstances reasonable suspicion, as in acute appendicitis, not only justifies but demands immediate operation. The dangers of delay are far greater than the hazards of surgery.

Grateful acknowledgment is hereby made to Drs. George C. Adie, Nelson W. Cornell, Frank Glenn, William F. MacFee, Edwin G. Ramsdell, and Preston A. Wade, Chiefs of the Surgical Services at the following hospitals: Grasslands, Mount Vernon, New York, St. Luke's, White Plains and New York City, for their courtesy in making available the records of those institutions in connection with this study.

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DISCUSSION OF PAPERS BY DRS. NEWELL AND BOSWORTH

R. Arnold Griswold (Louisville, Ky.): The question of non-penetrating abdominal trauma is a very difficult one. The spleen, the liver and kidneys are perhaps the organs most frequently injured, but injuries to the hollow viscera are usually more difficult to diagnose and operation is therefore frequently delayed.

X-ray of these patients is likely to lead to a false sense of security since, as has been pointed out, in only a small percentage is the laceration productive of air under the diaphragm. The injury

is usually to the small bowel where it has a short mesenteric attachment, and in a considerable percentage of cases, may not involve immediate perforation of the bowel. There may be delayed perforation due to necrosis of injured bowel.

I have seen three cases in which the mesentery was torn from 6 to 8 inches of the upper jejunum or lower ileum without perforation at the time. Perforation, however, may ensue three, four or five days later from gangrene of the detached bowel.

In any suspected non-penetrating wound I believe it is safer to explore than it is to procrastinate in order to make a definite diagnosis. The risk of unnecessary exploratory operation, if the patient is out of shock, is certainly much less than the risk of delay in these cases.

The liver injuries that Dr. Newell mentioned are severe and I should like to stress one point that he made, and that is to avoid gauze packing. Gauze packing of a wound of the liver, in which the gauze is left in as a drain, is almost universally followed by live infection and secondary hemorrhage. These patients whose livers are packed with gauze will usually die a week or two later of secondary hemorrhage. The newer hemostatic agents, such as large sheets of gelfoam or the oxycel products are preferable to any type of permanent gauze packing.

Any dead liver with detached fragments which are deprived of their blood supply should be very carefully removed; since autolysis of liver tissue in the abdomen is not only extremely serious but frequently fatal, and is the cause of a great many cases of what we used to call the hepatorenal syndrome.

Grover C. Penberthy (Detroit, Mich.): Both of these papers have emphasized the principles which are sound in the management of abdominal injuries of a non-penetrating type.

My discussion will be limited largely to Dr. Bosworth's paper in which he has shown the low incidence of this type of injury. He mentioned that in this study one out of 10,000 are injuries of this type of the small intestine.

The report of cases which I wish to add to Dr. Bosworth's collection are cases from the Detroit Receiving Hospital operated upon by members of the staff and two from the Michigan Mutual Hospital in Detroit.

For the study of these cases I am indebted to Dr. J. H. Posch, resident of the Receiving Hospital, who energetically surveyed the records of the Receiving Hospital. We find that our incidence of this type of injury is about one in 8,000 for hospital admissions and about one in 3,000 of surgical admissions.

In the study from 1935 to 1938 at the Receiving Hospital we had five cases which Dr. Posch was able to pick up. Since the advent of chemotherapy in a similar three-year period from 1943 to 1946 we had eleven cases with three deaths. In a series of five cases prior to chemotherapy in 1935 to 1938 we had a mortality of 100 per cent, showing the seriousness of this lesion and the importance of early recognition.

Lester Breidenbach (New York, N. Y.): At Bellevue Hospital on the 4th Division it is by far safer to come into the hospital with a gunshot wound or a stab wound of the abdomen than it is with blunt trauma to the abdomen, because the patient gets operation sooner, and therefore the mortality is less.

We have had six cases in the last twenty years in which the mortality was 50 per cent. The first case that I saw was twenty years ago. A fifty-five year old man, who was carrying a large, round cheese clasped on his abdomen and chest, tripped and fell on the cheese. It seemed like an insignificant trauma; the fall was not from a great height and yet he was put on watchful waiting for seventy-two hours and then died. Autopsy showed a complete transection of the jejunum about 12½ inches from the ligament of Treitz.

In spite of that experience we had other cases admitted, almost all with the same story: watchful waiting, delay in operation and death because of associated severe peritonitis and toxicity.

In the last two cases in more recent years, one had a duodenal injury and that was the only one of the six that showed air under the diaphragm. The jejunum and ileum cases did not show air under the diaphragm. The patient with a duodenal injury was operated upon seven hours after admission and did well. The sixth case was that of an ileum laceration, not transection; the patient was operated upon promptly and got well.

I think the main clinical picture is persistent pain, tenderness and leukocytosis with polynucleosis. If that is recorded and persists, I think it is a definite indication for exploration as early as possible.

Concerning Dr. Newell's paper, we have had one very interesting case of a transection of the common duct at the junction of the two hepatic ducts. This man was driving a truck in a high cab, was hit by another truck and somersaulted out of the cab of the truck, landing on his abdomen, hitting the front mudguard on the way down to the ground. He was brought to the hospital in slight shock, not very severe, but as time went on his abdomen became distended with fluid. He developed mild jaundice and at the end of sixty hours was operated upon. He had 3,200 cc. of bile in his abdomen, and this laceration at the junction of the common and hepatic ducts was found and repaired. He did well for a short period of time. He had about seven admissions to the hospital in the course of three years, each time with chills, fever, cholangitis and jaundice. On several occa-

sions he was not opened but was treated. The chills, fever and jaundice subsided and he would go along again for a time feeling pretty well until he had a recurrence. On two occasions he was opened, redrained and reconstruction done, but finally he succumbed at the end of three years to a typical cholangitis liver death.

CALEB HOWARD SMITH (Bradford, Pa.): I had a personal case of rupture of the gallbladder in a young man about seven years ago. I performed a cholesystotomy because I believed suture of the gallbladder would not be reliable, and biliary peritonitis made cholecystectomy somewhat dangerous. This patient had gone a week following his rupture and then came to the hospital intoxicated. The patient did very well and follow-up studies two years later indicated he had a good result.

A second case I would like to mention is that of a rupture of the small intestine due to blunt trauma. In a recent case a rupture of the ileum was sutured over within six hours because the patient had an obvious peritonitis. There were several other areas, as much as a foot away, which were definitely bruised and a danger of slough postoperatively was imminent. A Miller-Abbott tube had been placed in this patient before operation, and following operation the tip of the tube proceeded into the ileum. I believe this may have afforded the patient some protection against a secondary slough.

LAURIE H. MCKIM (Montreal, Canada): I wish to emphasize the point that has been emphasized by Dr. Bosworth, namely, the question of persistent pain.

I wish to tell you a story of an accident that happened where there was more than one injury. I do not think this point has been stressed by either of the authors. A jockey of about twenty-three years of age was injured by a severe fall at about 4 P.M. and was brought to the hospital. We could not get very much history as to just what happened. The horse fell and rolled over on the patient and he was brought to the hospital in most profound shock.

Examination showed very little in the line of external trauma except a small bruise in the upper left quadrant. The man was obviously suffering from shock and the blood examination revealed there had also been considerable blood loss. He was x-rayed and there was no gas shadow.

About three hours later he was operated upon. On account of the persistent pain and the bruise in the upper left quadrant, he was explored through a left abdominal incision in the upper half. Examination showed a perfectly huge hematoma with the omentum torn almost entirely across and bleeding freely. This was controlled and the vessels tied. The tear in the omentum was so severe that the lower part of the omentum was removed. It was believed that that was quite sufficient to account for his symptoms. Therefore, the abdomen was closed and he was given 500 cc. of blood.

He continued to complain of severe abdominal pain after he recovered from the anesthetic and died about twenty hours after injury. The postmortem examination revealed a complete tear of the small intestine about 4 feet above the ileocecal valve. The remarkable fact was that although the man had a rapidly spreading streptococcic peritonitis, there was practically no soiling of the abdomen.

I present this as one of the cases in which there may be more than one injury, and in which hemorrhage may confuse the operator and cause him to miss a second lesion.

CHARLES HUGH MAGUIRE (Louisville, Ky.): I was interested in Dr. Newell's paper because we had one of these so-called traumatic cholecystectomies several years ago. This was a young man about thirty years of age who was thrown from the back seat of an automobile against the back of the front seat. At the time of admission he was not in any particularly serious condition; however, he complained of continuous abdominal pain which I considered to be a sign of utmost importance.

After about four hours he was explored and upon entering the abdominal cavity about 500 cc. of blood-tinged fluid was encountered. No definite injury to any of the major viscera was found; but on aspirating the cul-de-sac, an intact gallbladder appeared hanging to the end of the suction tip. Exploration of the upper abdomen revealed as clean a cholecystectomy bed as you would desire in an elective procedure.

The cystic duct and cystic artery were standing up nice and clean. There was a little bile draining from the cystic duct and the cystic artery was thrombosed. Ligatures were placed around both of these structures and the abdomen closed. The patient made a very uneventful recovery.

One other thing of importance is our present day use of contact clotting mechanisms in the form of gelfoam and oxidized cellulose. These contact clotting agents have given us a very useful adjunct in the treatment of these lacerations.

ROSCOE C. WEBB (Minneapolis, Minn.): For the sake of the record I would like to mention briefly a rupture of a bile duct. The patient was a thirty year old truck driver who had been in an accident. I saw him two weeks after the injury when it was thought he had a ruptured diaphragm. His chest had been aspirated and bile had been obtained, mixed with fluid, apparently because the needle had gone through the diaphragm.

I put in the trocar and cannular catheter to aspirate, with a mechanical suction apparatus. My catheter went in about 12 or 14 inches and an x-ray later showed that the catheter went down

midline in the region of the lower attachments of the diaphragm.

I got out a huge quantity of pure bile. I kept this up with mechanical suction for several days and the patient recovered. The fact that he had pure bile with no blood mixed with it and the fact that he recovered rather pointed against it being a rupture of the common duct or a rupture of the gallbladder, and it was all superdiaphragmatic; but the treatment of aspirating the subphrenic space worked.

I would agree with Dr. Bosworth on the difficulty of diagnosing ruptures of the small intestine. I recall three cases. The first patient, a young boy, was kicked by a horse in New York and was taken to the hospital and then sent home. He was brought to the hospital where I was house surgeon twenty-four hours later, with an obvious peritonitis. He was operated upon and recovered.

A second case occurred in Montana. The patient was hit by a revolving wrench fastened to a machine, which let go and hit the man in the lower abdomen. He was brought to me about three weeks later. He had a massive abdomen with obstruction. I operated and found he had perforation of the small intestine in the region of the lower lumbar vertebra. This patient was an example of one who had had a rupture of the small intestine and who recovered.

A third case was that of a man who was injured at 8:15 A.M. This is comparable to the "cheese" patient. He had a pail against his abdomen and somehow or other it twisted in his clothes and pushed against his lumbar spine. He had some pain but kept on working. He worked until 12 o'clock and then went home. He was seen by a doctor at 2 P.M. when he was thought to have a perforated duodenal ulcer. He was operated upon ten hours later and recovered.

BOARDMAN M. BOSWORTH (closing): I continue to be amazed from time to time at the modesty of doctors in general, and of surgeons specifically. This morning in the discussion you have heard many cases reported. I lost track of them. Why did not these doctors publish those cases in the literature? If they had, I would have had a much better paper to present myself.

I would like to mention the use of omentum. As you all know, it is a very useful thing in a laceration of the liver to tie a tag of omentum in with your sutures if the hemorrhage is not too great.

We have used the diagnostic tap of the abdomen when any peritoneal injury was suspected from time to time at City Hospital in New York City. Our results were not all we had hoped for. Therefore, we have discontinued its use. If we believe the tap is justified, we believe that an exploratory incision is justified and will give us a great deal more positive information.

RÔLE OF CHEMOTHERAPY IN WOUNDS AND SURGICAL INFECTIONS*

A STUDY OF THE SIGNIFICANCE OF GRAM-NEGATIVE PATHOGENS IN FRESH TRAUMA AND CHRONIC INFECTIONS

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IN a previous article[3] the authors dealt with the significance of contamination of fresh wounds and of pre-existing infections with certain pathogens and particularly with gram-positive pyogenic bacteria. About 500 clinical cases occurring over a four-year period were studied. These were analyzed and certain observations and deductions made. In particular, the rôle of local and systemic chemotherapy was discussed. A similar study dealing with the significance of gram-negative pathogens in fresh trauma and pre-existing infections is now presented. This report covers the clinical and bacteriologic studies in fifty-four patients from the surgical wards of The Montreal General Hospital. The small proportion of these gram-negative cases[54] out of a total of over 500 cases in the whole series is a point we believe worth emphasizing. This fact made it desirable to delay our report to allow for the accumulation of a representative, although still small, series.

The details of the technic of surgical management and method of bacteriologic sampling have been described previously.[3,9] At the risk of repetition these are briefly reiterated: They involved taking bacteriologic samples from wounds at operation and dressing changes as well as through "lucite" windows incorporated in a standardized form of occlusive compression dressing. This last was made necessary since dressings were invariably infrequently changed, not less than a week and often over a two weeks' period of time. We considered that more frequent bacteriologic sampling was desirable and this was done as often as twice weekly on the average.

To facilitate the studies a standard method of surgical management was adopted which observes the best known and approved surgical principles. It is flexible enough to be adaptable to all forms of trauma and infection which might be encountered. It has already been described in the literature and it will suffice merely to enumerate the principles of the technic:

1. Delay of surgery until shock and hemorrhage are adequately controlled.
2. Surgical asepsis.
3. Preparatory washing with soap and water and copious saline lavage.
4. Appropriate timing of initial and subsequent surgical procedures.
5. Adequate surgery—initial and subsequent—including (1) excision of wound or infection—minimal, partial, maximal, often inadequately referred to as débridement; burn blisters were opened and débris was generally removed; (2) incision and counter-incision of wound or infection for relief and prevention of tension and for drainage; (3) wound drainage by oily pack, referred to as "curtain drainage"; (4) suturing: primary suture reserved for chest, head, face, joint, nerve and tendon cases; delayed primary is the general practice except in special cases. This is possible at any time during the first three weeks with revision of the wound; secondary suture at a later date, implying wound revision because of organizing granulation tissue. All suturing is done loosely to prevent tension, with its inevitable risk of edema and danger of local bacterial multiplication. Primary, delayed primary and secondary split-skin grafting are terms employed with the same significance as applied to suturing.
6. Bacteriostasis: From the foregoing it will be seen that natural bacteriostasis is given full play. It is supplemented by bacteriostatics as innocuous as possible to the reacting tissue, free or fixed.
7. Compression: Immobilization by massive occlusive compression dressings of the whole

* This work was carried out under the auspices of the National Research Council of Canada.

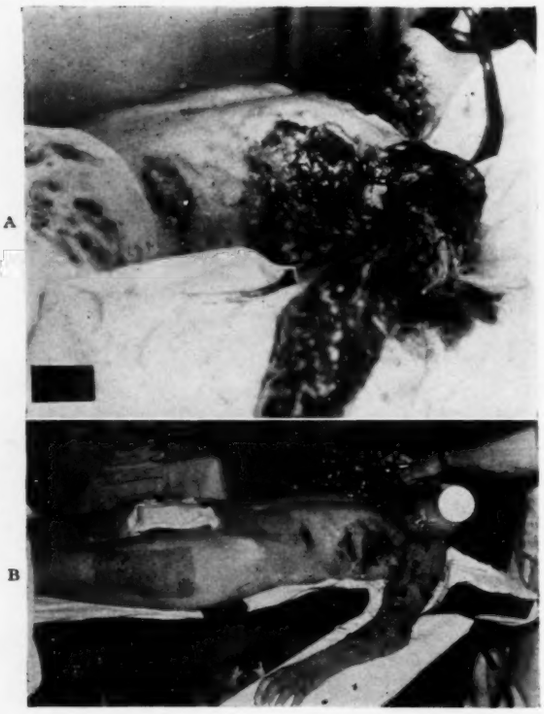


FIG. 1. Case 3. A, 30 per cent burn at eighteen days heavily contaminated with Pseudomonas pyocyanea (blue pus). Granulations removed and delayed primary split-skin grafting of about half of area; further grafting at thirty and forty-two days without loss of graft. B, same case at forty-two day grafting, dressed to receive a few final skin patches. All were successful despite persistence of "blue pus" throughout.

part. The large bulk of cotton waste gives uniformly distributed elastic compression and drainage. By this means the vascular circulation is not impeded and is probably facilitated. Lymph stasis and edema are minimized while in surface wounds and burns plasma loss by wound oozing is lessened. Moreover, the normal mechanism controlling capillary oozing is assisted. Light plaster encasement is added at times for additional immobilization as in compound fractures of long bones. Internal fixation is done when necessary.

8. Timed infrequent change of dressings: Prevention of secondary infection is the main reason for infrequent dressing changes. This should mean not less than weekly and more often longer, while in long bone fractures much longer intervals are required to allow for callus formation. Dressings should not be removed for observation purposes. They should be removed only for definite reasons: to wit, for planned surgery because the wound is healed, or in the very rare occurrence of adverse signs and symptoms.

9. Topical therapy: For bacteriologic observation and investigation three materials were used in an oily base for packing purposes as follows:

1. A 5 per cent emulsion of sulfathiazole was employed in most of the cases because of our experience with its successful elimination of the pyogenic streptococcus, always a menace initially or as a subsequent contaminant. It has no influence upon the presence of gram-negative pathogens.

Sulfathiazole Emulsion (M.G.H. Formula)

	Per Cent
Sulfathiazole	5
Triethanolamine	2
Distilled water	24
White beeswax	5
Liquid paraffin	64

2. A penicillin cream (1,500 units per Gm.) was used in a number of patients who were known to have staphylococcic contamination. This showed no effect upon gram-negative pathogens. Additionally, it did not tend to eliminate the pyogenic staphylococcus.

Penicillin Cream (N.R.C. Formula)
(1,500 Units per Gm.)

	Per Cent
Z 2 Stearic acid	15
Lanolin	8
Mineral oil	25
Water to	100
Carbitol	5

3. A streptomycin cream (10,000 units per Gm.) was employed in four pre-existing infections (chronic leg ulcers) two each infected with Pseudomonas pyocyanea and Bacillus proteus vulgaris. It had no effect upon these organisms. It was noted, however, that they regularly and rapidly (in a few days) become streptomycin-fast.

Streptomycin Cream
(10,000 Units Per Gm.)

	Per Cent
Stearic acid	10
Cetyl alcohol	5
Spermaceti	8
Lanolin	15
Water to	100
Glycerine	10

Fresh Trauma—Twenty-six Clinical Cases. Pseudomonas pyocyanea was a contaminant in

A B

C

FIG. 2. Case 25. A and B, 60 per cent deep and superficial burn showing state of slough heavily contaminated with Pseudomonas pyocyanea and Bacillus proteus, eighteen days after admission. C, three months after admission; healing is complete although both organisms persisted throughout seven skin grafting operations at nine-day intervals.

twelve of these and persisted in nine until healing was complete. Of these twelve clinical cases, three were delayed primary sutured wounds and seven delayed primary split skin grafts. *In not a single instance was primary healing delayed,* despite persistent organisms. Cases 3 and 25 are perhaps particularly noteworthy. These were 30 and 55 per cent burns and had successive split-skin grafting at nine to 10 day intervals, starting at the end of the third week, and the grafting was done in the face of heavy contamination with Pseudomonas pyocyanea, Bacillus proteus and Pseudomonas pyocyanea, without interference with healing. On the contrary, it was entirely successful and we have had many other similar experiences. (Figs. 1 and 2.)

There were thirteen contaminations with proteus vulgaris and the organism persisted until healing in most instances. Despite this, eleven of these cases including five skin grafts had uninterrupted primary healing. In three cases, 11, 12 and 20, there was some delay and/or loss of skin graft. The delay in each instance could be explained on the basis of constant recontamination of ineffectually dressed wounds of buttock and thigh.

Every surgeon will bear witness to the practical impossibility of preventing recontamination of such wounds. Their dressing problem

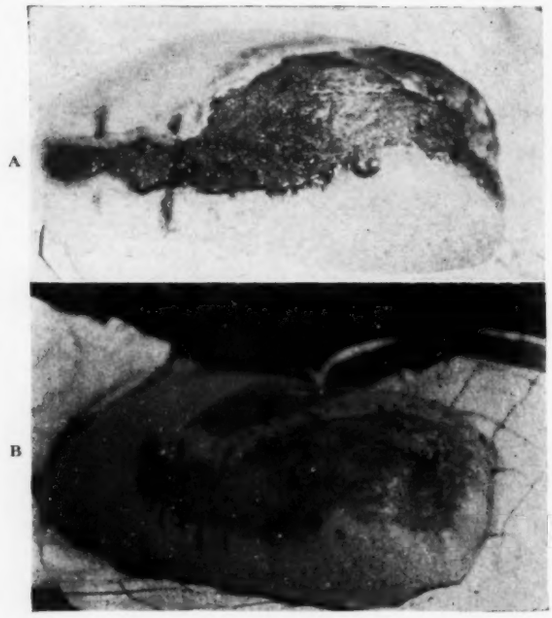


FIG. 3. Case 26. A, revision of thigh amputated at twenty-one days with delayed primary split-skin grafting and suture; Bacillus proteus pus present; note healthy granulations removed as usual for grafting bed. B, same case at forty days showing complete healing despite persistence of Bacillus proteus to healing.

FIG. 4. Case 16. A, crushed leg with compound fracture dislocation of ankle; illustration shows extensive slough starting to demarcate at twelve days; Bacillus proteus present. B, same leg still heavily contaminated with Bacillus proteus at twenty-four days; wound was revised and grafted at this dressing. C, primary healing with persistent culture of Bacillus proteus.

is perhaps best settled by appropriate posture, exposure to the air and adequate nursing; although sometimes as with skin grafting, it is both necessary and desirable to produce clinical obstipation for several days while using an occlusive compression dressing.

Escherichia coli and coliforms were cultured in six cases, but in no instance presented any clinical problem whether alone or co-existent with other organisms.

Clostridium Welchii co-existed in three instances as a contaminant but disappeared before healing and without infecting. (Figs. 3 and 4.)

Pre-existing Infections with Gram-negative Pathogens—Twenty-eight Cases. In thirteen cases of chronic infection with Pseudomonas pyocyanea, surgical revision and delayed primary suture or split skin graft were carried out. Some delay in healing occurred in two instances. One was a delayed suture in an eighty-four year old debilitated and arteriosclerotic man (Case 3), with gross, chronic osteomyelitis of the femoral trochanter. It was impossible to do a complete sequestrectomy and he developed a persistent sinus which finally healed. The second patient (Case 13) had large bilateral chronic leg ulcers with particularly poor circulation. She was a drug addict and extremely debilitated. We were rather surprised to have successful delayed primary grafting on the one side and ultimate success with the other. (Fig. 5.)

Of fifteen chronic Bacillus proteus infections having surgical revision and delayed suture and skin graft, four cases (14, 17, 21 and 23) showed some delay in healing. Of these Case 14 was an old traumatic leg ulcer involving the tibia with much loss of muscle and other tissues and consequent great scarring and poor circulation. Case 17 was a vagabond in whom the circulation of the extremities was very poor but results were ultimately successful. Case 21 had several deep sinus tracts running in old scar from old femoral osteomyelitis and Case 23 actually had tuberculous tissue found on first excision and so might be excluded.

The occasional[3] coliform cultures occurring in conjunction with the other gram-negative organisms appeared to have no influence upon

the fate of the case or the other organisms. It should be worth recording at this point that in our whole experience with trauma and infections (over 450 cases) we have had only one instance in which coliforms appeared significant, a primary skin graft referred to in our previous report.[9]

Comment. Pyogenic staphylococcus was present in 55 per cent of the cases but was found to be without any significance even when persistent to healing. Pyogenic streptococcus occurred much less frequently and then only on initial cultures. It regularly disappeared early and we believe has no significance in these cases. In not a single instance did invasive infection develop. Cl. Welchii co-existed in three clinical cases with gram-negative organisms but without producing clinical disease.

Although actual invasive infection with these organisms has not been common in our series, we have met with a few of these problems. In these instances the use of streptomycin intramuscularly in 2 Gm. doses for ten-day periods has been highly successful.

M. F., a twenty-five year old nurse, entered the hospital first in 1938 with slowly developing abscesses of the subcutaneous tissue and fascia of the lower abdominal wall. These contained frank Bacillus proteus pus and had definite burrowing characteristics. From the first to the last, until July, 1947, this patient's history has been an almost continuous succession of similar burrowing subcutaneous and fascial abscesses over an area extending from the waistline down to the mid-thighs. During most of this time she has been in the hospital. (Fig. 6A and B.)

Radical excision of the involved areas, particularly of subcutaneous and scar tissue, with split-skin grafting seemed to check the infection locally, but new abscesses appeared in adjacent old scar areas at intervals of weeks or months. In July, 1947, she had an abscess in the scarred thigh and this contained the usual Bacillus proteus and also Staphylococcus pyogenes, unfortunately penicillin-fast. After excision she was given streptomycin intramuscularly, 2 Gm. daily for ten days, in divided doses of 0.5 Gm. The Bacillus proteus disappeared at once from the lesions and has never been recovered since, although she continued to have occasional staphylococcic abscesses in the scars. Figures 6C, D and E show the histology of this patient. Six months later the patient had the old scar excised and successfully grafted primarily. The patient is now clinically well for the first time in years.

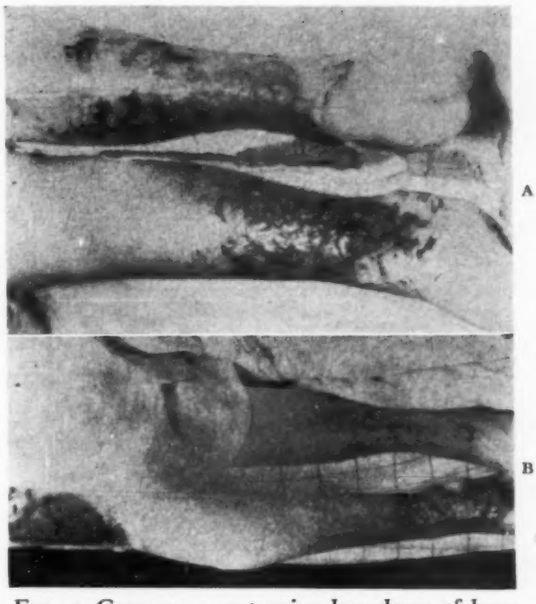
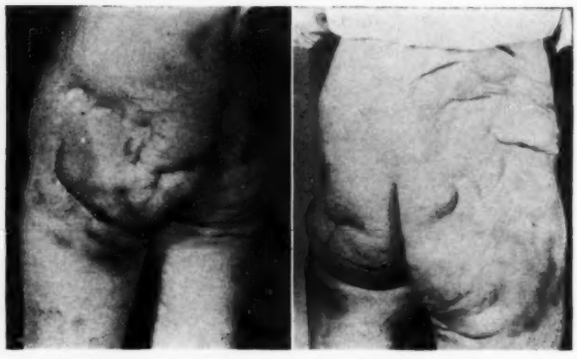


FIG. 5. Case 13. A, extensive leg ulcers of long standing with very poor circulation. The ulcers had previously been excised and now after sixteen days the granulations shown were excised again and split skin grafting done. There was a heavy growth of Pseudomonas pyocyanea on the left leg and of Bacillus proteus on the right leg. B, same case at thirty days (two weeks after grafting) showing complete take of graft on left leg and incomplete on the right leg. The patient, an uncooperative drug addict, left the hospital refusing further treatment.

In another instance of acute invasive infection we have observed apparent synergism between streptomycin and penicillin. Pneumonia which supervened during the third week of hospitalization responded well to penicillin. However, remittent and continuous fever which developed in the fifth week did not respond to either penicillin or streptomycin alone, but dropped *promptly* with combined therapy of 2 Gm. of streptomycin and 300,000 units of penicillin daily.

Finally it would appear from our experience that when gram-negative pathogens actually cause clinical problems by invasion, the general or local physiologic conditions are to blame, and that surgery and antibiotics interdependently appear satisfactory answers to the problem.



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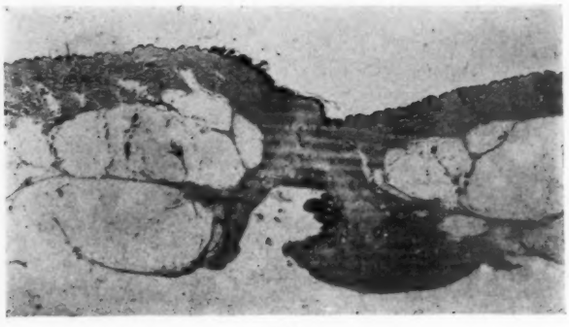

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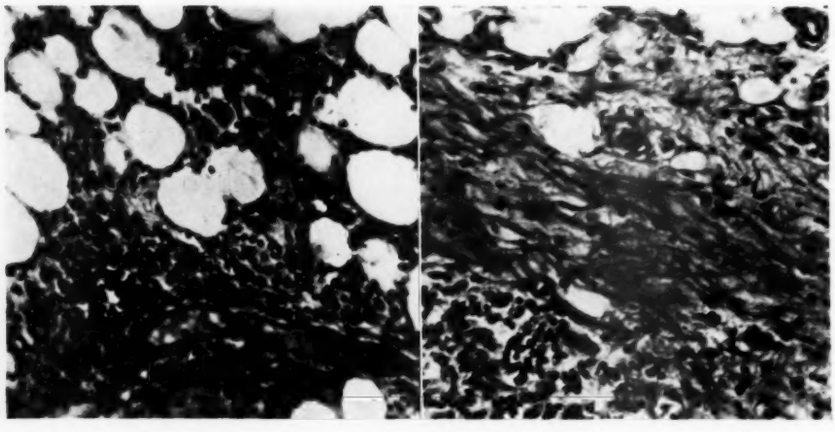

D E

FIG. 6. A and B, results of chronic subcutaneous infection of eleven years' duration showing much loss of tissue from numerous wide excisions, scarring and skin grafting. C, low power view of section of skin and subcutaneous fat through site of previous excision. In the center of the section there is a depressed scar in the skin extending into the fat. In the subcutaneous part of the scar is the cavity of an abscess lined by granulation tissue which shows as a dark membrane heaped up on one side. D, section of subcutaneous fat showing heavy infiltration with inflammatory cells chiefly lymphocytes with fewer polymorphonuclears and large phagocytes. E, section of margin of scar in the subcutaneous tissue showing nonsuppurative inflammatory exudate and fibrosis incorporating fat cells.

SUMMARY

The foregoing study reveals the following pertinent facts:

1. Gram-negative pathogens are by no means the most frequent contaminants met with in fresh trauma (twenty-six cases in over 250) or in surgical infections (twenty-eight cases in over 300).

2. When present they are most often found in lower extremity lesions.

3. In both fresh trauma and surgical infections these organisms tend to persist even though their presence rarely causes delay in healing.

4. In fresh trauma despite their persistence, these organisms show almost no tendency toward invasive infection when sound wound management is applied and circulation is adequate. Consequently, delayed, revision surgery and skin grafting may be done with relative impunity.

5. In pre-existing surgical infections with gram-negative pathogens, revision grafting or surgery is almost equally immune when local and general physiologic conditions are satisfactory, even though contamination be gross.

6. The corollary to this statement is that adequate blood supply and all other physiologic conditions should be zealously protected in every wound or surgical infection.

7. These physiologic conditions are well maintained locally as indicated[3] by some form of occlusive compression dressings infrequently changed. The authors believe strongly in the rôle played by these dressings in wound healing. Maintenance of the general physiologic condition requires no comment here.

8. No evidence has been adduced clinically in trauma that symbiotic influence as between gram-negative and gram-positive pathogens exists.

9. Such bacteriostatics and antibiotics as we have used topically with the technic described, including sulfathiazole, penicillin and streptomycin in cream bases, have regularly failed to eliminate gram-negative pathogens in fifty-four cases of fresh trauma and surgical infections.

10. Streptomycin in a cream base has quickly and regularly caused "fast" organisms in four instances.

11. Contrary to these results the authors have been greatly encouraged in this work by these more recent experiences with streptomycin when used in certain gram-negative infections with specific technics and have cited certain of these experiences.

12. When invasion by gram-negative organisms does occur, intramuscular streptomycin has given very encouraging results in the few instances so far observed.

13. We have seen an apparent synergistic effect between penicillin and streptomycin in one instance.

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THE SIGNIFICANCE OF GRAM-NEGATIVE PATHOGENS IN RECONSTRUCTIVE SURGERY

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Montreal, Canada

RECONSTRUCTIVE surgery from simple split-skin grafting to complicated pedicle maneuvers is often necessary in areas and regions heavily contaminated with gram-negative pathogens. Past teaching has indicated the presence of these organisms to be dangerous and to jeopardize the outcome of such procedures. In the light of present day wound-patient management it would seem these pathogens are merely contaminants and have little, if any, adverse effect on the result of the plastic surgery that is done.

FIG. 1. An occlusive pressure dressing in an extensively burned patient. Children are comparatively comfortable and the dressing need only be changed every seven to ten days under anesthetic when further wound revision or skin grafting is indicated.

True, this places a new aspect on those old offenders, Pseudomonas pyocyaneus, Bacillus proteus and Bacillus coli formerly thought to be so malignant. Yet the teachings of the late Dr. Fraser Gurd and the work of Ackman and Smith[1] and other collaborators at McGill and the Montreal General Hospital seems to throw them in a much less baneful light. The experiences of plastic surgeons in general and their developments of the last few years seem to confirm this line of thought. A brief survey of their methods and the surgery accomplished in the obvious presence of gram-negative pathogens should be timely.

Present surgical teaching dictates that patients will not be operated upon electively unless they are in a certain state. This is simply that they shall not be debilitated, their morale shall be good, that they shall not be anemic and that their blood proteins shall be at or near normal levels.

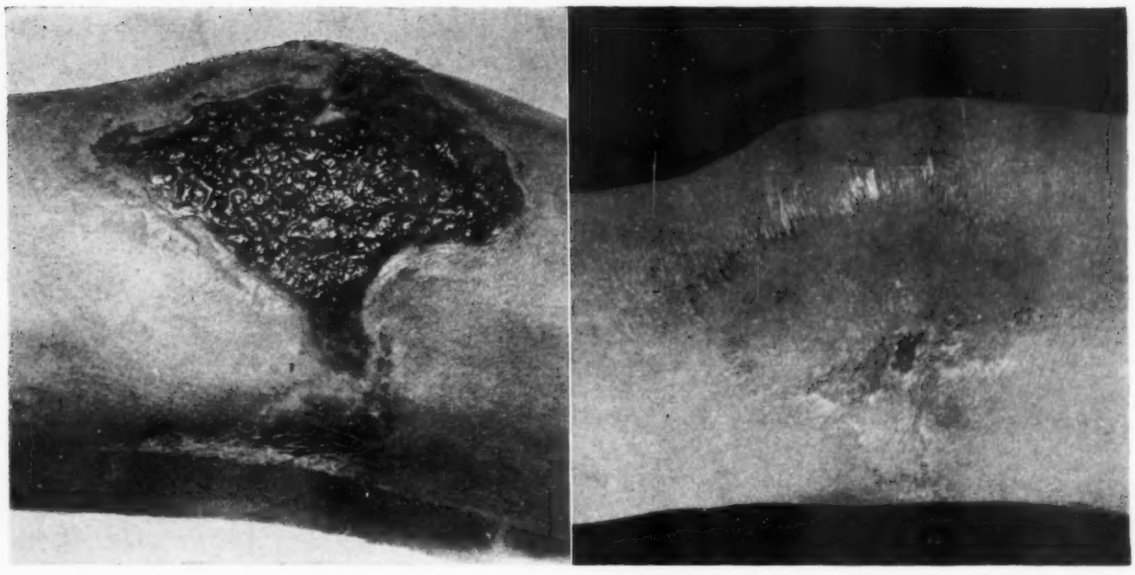
Present surgical teaching also dictates that an effort shall be made to produce a certain wound state, to bring the wound into a healing phase. This means simply that the wound shall be healthy and show early signs of healing, in other words, that the wound be in a receptive state for grafting. Occlusive pressure dressings (Fig. 1) are very helpful in placing both the patient and the wound in these desirable states. Débridement of the wound is often a very helpful short cut. Meticulous graft care and postoperative fixation need no emphasis.

With these factors in operation, gram-negative contamination will be at a minimum, and what there is will be relatively harmless to a variety of reconstructive procedures that may be carried out.

Indolent Wounds. Indolent wounds with exuberant granulations harbor gram-negative pathogens. Theoretically, they are not satisfactory for grafting as the secretions tend to lift up the graft. A week or ten days would be well spent in improving the wound state with occlusive pressure dressings. However, débridement may be an indicated short cut. If the patient state is good and the wound not too large and in a place where an effective postoperative dressing may be used, débridement down to a firm bleeding basis will remove the gram-negative pathogens and permit satisfactory grafting. (Fig. 2.)

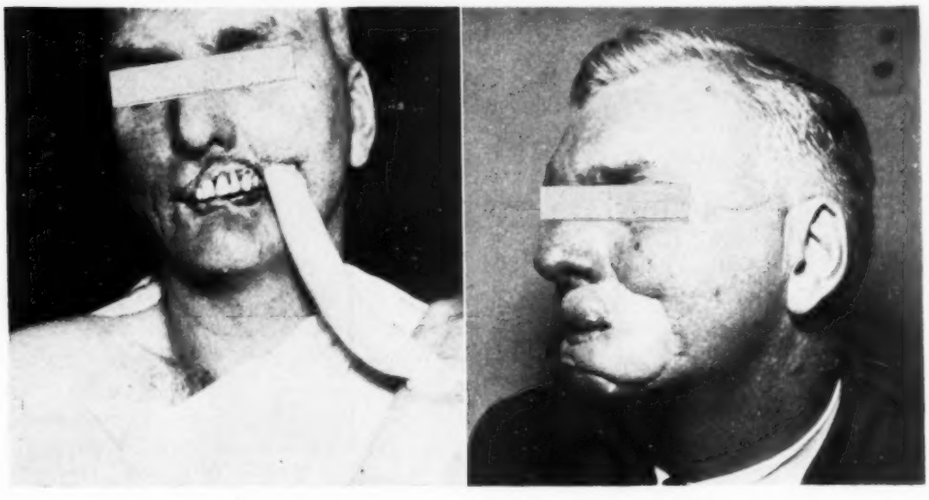
Grafting about the Mouth. Split-skin grafting in the mouth, employing a stent technic, has always been a certain procedure, this in the face of saliva and both gram-negative and gram-positive infection. The stent just pushes the organisms out of the way and provides the requisite pressure for graft take.

On the other hand, pedicle grafting about the mouth (Fig. 3) is a more hazardous procedure



A B

FIG. 2. A, small indolent wound suitable for débridement and grafting; B, the result.



A B

FIG. 3. A, tubed pedicle grafting to the mouth indicating the difficulties of wound control; B, grafts do take in spite of these difficulties.

because of the continuous movement, the presence of mouth infecters and the impossibility of using stent or pressure dressing. No precise control of these adverse factors is possible. Yet pedicles do take reasonably well in the face of these obstacles.

Grafting about the Anus. This is a region obviously contaminated with gram-negative pathogens. Yet if bowel movement is held in check for four or five days, grafting of both the split-skin variety and rotation pedicle types is fairly certain. A rather wide experience with rotation flap maneuvers to close ischial ulcers in paraplegic patients has proved this conclusively.

Grafting in Extensive Burns. In the extensively burned patient all factors seem to be working against the successful grafting of the patient. Debilitation sets in, morale deteriorates, anemia and hypoproteinemia are hard to control and the wounds become indolent and loaded with gram-negative pathogens. (Fig. 4.) The patient's debilitation and anemia will permit little or no débridement. Yet by vigorous pursuit of all these adversities, grafts do take or take in part. The gram-negative pathogens are pushed aside, the patient's condition improves with each grafting and the burn wounds are eventually healed. Langhor, Owen and Cope[2] have recently pointed out the frequency

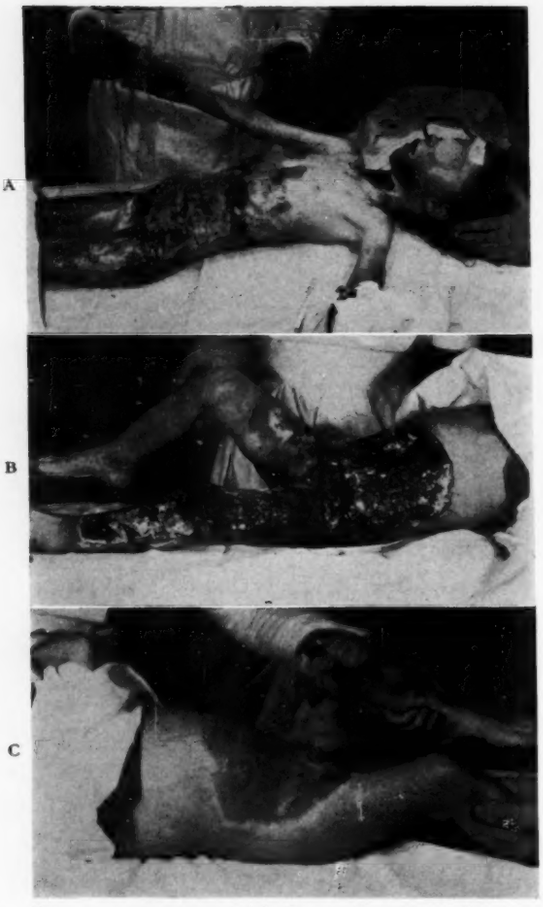


FIG. 4. A, an extensively burned patient showing obvious debilitation anemia, hypoproteinemia, wound indolency and contamination. B, an extensively burned patient in whom debilitation and anemia have not yet become apparent. The wound is contaminated with B. coli and proteus. C, the same patient as in B three weeks later showing autografts on the abdomen and beginning dissolution of homografts on the leg. (Negative has been reversed in printing.)

of infection with gram negative pathogens of burn wounds of the trunk, buttock and lower extremities.

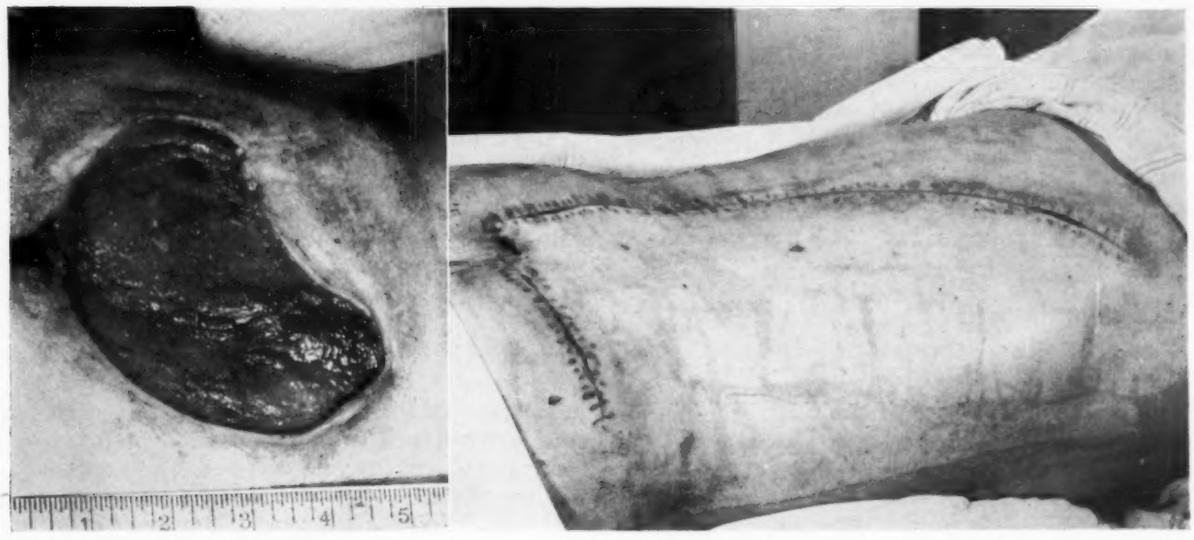
Decubitus Ulcers. The results produced in many centers in the grafting of decubitus ulcer sites of paraplegic patients should put the final quietus on this gram-negative bugaboo. These ulcers are principally in the sacral, ischial and trochanteric regions and, therefore, in spite of careful dressing technics are invariably contaminated with Bacillus coli and Bacillus proteus. In a recent article, Gerrie and McNeil[3] have admitted an early invasive phase in the production of the decubiti when both gram-positive and gram-negative infecters carry on invasive and destructive activity. However, given this same patient with two to three weeks' care in a paraplegic center, with attention to patient and wound care, the ulcer can be brought to a healing phase when it is ready for any reconstructive procedures (Fig. -) and the gram-negative pathogens have little if any hindrant effect.

Bone Cavities of Chronic Osteomyelitis. One of the interesting contributions of war surgery has been the combined orthopedic and plastic approach to the treatment of infected bone cavities. The work of Shannon and Woolhouse[4] at the Queen Mary Veteran's and Montreal General Hospitals has been one of these contributions. Their cases have been mostly of the traumatic, exogenous type of osteomyelitis with a mixed infective factor, gram-negative pathogens being commonly present. Fifteen years ago it was taught that you could not skin graft on bone. Now the bone and adjacent tissues are débrided widely, the infection cut out and the bare bone is skin grafted with a gratifying percentage of take. (Fig. 6.) The osteomyelitis is cured and subsequent cross-leg or other types of pedicle grafting fill out the contour of the leg at a later date.

Grafting Mastoid Bone Cavities. The grafting of an infected mastoid cavity following radical mastoidectomy is a somewhat similar procedure that has been done for years. This cavity often contains both Bacillus coli and Bacillus proteus as well as other stringy, mucus producing gram-negative contaminants from the mouth and yet grafting here meets with a fair measure of success.

Reconstruction of the Urethra and External Genitalia. Reconstruction of the congenitally absent vagina entails split-skin grafting of a large cavity created between the rectum and the bladder. McIndoe and Banister[5] have done this using a vulcanite mould. Owens[6] prefers a pyrex form while Adams[7] uses ordinary rubber sponge cut to the desired shape and size to carry the skin graft into position. These men have shown excellent results with complete skin graft take in areas obviously contaminated with gram-negative pathogens.

Resurfacing of the penis from which the skin has been lost because of accident or infection is not an uncommon procedure. The work of Brown[8] and Byars,[9] using a careful graft and dressing technic, has produced some startling results.



A B

FIG. 5. A, sacral decubitus ulcer in a paraplegic patient. B, closure of ulcer by a large flap after the method of Blascovic.

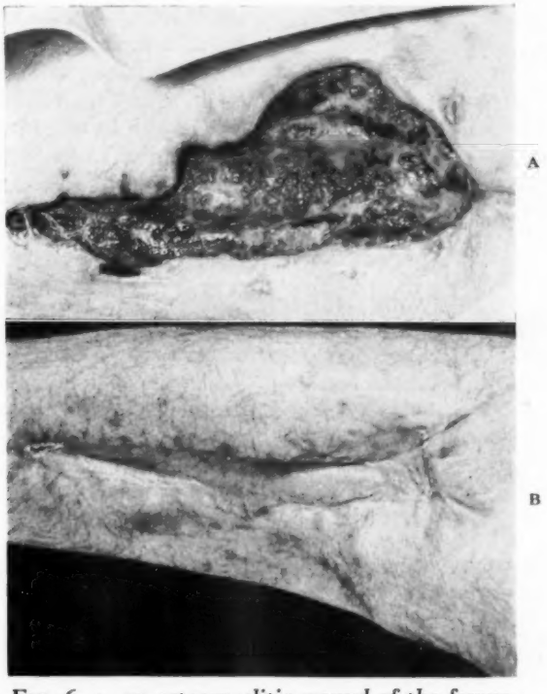


FIG. 6. A, an osteomyelitic wound of the femur. B, the same wound split-skin grafted before final revision.

Grafting of the male urethra both for congenital hypospadias and traumatic stricture is another common procedure. McIndoe[10] has popularized the inlay skin graft type of reconstruction and Young[11] has carried this to a further stage of perfection. Recently Gerrie and MacLean[12] have reported on the skin grafting of the bulbomembranous urethra in traumatic war cases.

The aforementioned reconstructive procedures carried out in areas contaminated with gram-negative infection would indicate a new assessment of the surgical significance of these pathogens.

CONCLUSIONS

1. Reconstructive procedures are commonly carried out in areas heavily contaminated with gram-negative pathogens.

2. With acceptance of present day conceptions of patient care with the correction of morale, anemia and hypoproteinemia, and with attention to wound detail of occlusive pressure dressing, débridement, graft fixation, etc., the gram-negative pathogens seem to be contaminants rather than infecters and have little or no adverse effect on reconstructive procedures.

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DISCUSSION OF PAPERS BY DRS. ACKMAN AND SMITH AND GERRIE

Laurie H. McKim (Montreal, Canada): The important thing appears to be that these men have done this work with a great deal of care. You will notice that Dr. Ackman said the bacteriology was done by one technician; the technic was the same for all cases. I do not think there is much chance for a slip of any kind in the bacteriology technic. We have been impressed with two or three things:

Those of us who are not doing this work ourselves believe that the success they have obtained is due largely to the infrequent compressive dressings. They keep the wound covered up. They dress wounds very infrequently and with very great care, controlling all cases by careful cultures. They have a very ingenious device for taking cultures through a little plastic window which they have placed in the dressing.

The two points we have been impressed with are, first, that the infections are controlled mainly because they keep them under continuous pressure dressings; secondly, when the thing is analyzed it would seem that under these circumstances the gram-negative bacteria are no great deterrent to grafting or to the revision procedure, and are probably of much less importance than they were thought to be.

There is just one point that Dr. Ackman did not mention. He has a very strong suspicion that in some cases there may be a synergistic action between penicillin and streptomycin. In one or two cases in which neither of these bacteriostatics were of any use whatsoever, they seemed to do something when combined.

Harry Hoyle Campbell (Toronto, Canada): I would like to point out that a properly prepared bed can usually be obtained in these ulcers. The use of the saline baths during the war led us to believe that while infrequent dressings were important early, when there was gross contamination with Bacillus proteus or Bacillus pyocyaneus, one could clean up the wounds very well with saline baths. While the ulcers would clean up clinically quite remarkably, cultures might still grow gram-negative and gram-positive pathogens.

However, grafting in the presence of gross infection is mainly a technical problem as the graft is floated off the bed by the exudates. This can be controlled in many ways, one, simply by putting the graft under tension when it is sewn down, because there is a lot of edema in the part anyway. When the patient is very ill and it seems imperative to cover the large ulcers fairly early, dressings of the wound may be done after twenty-four and forty-eight hours to open any small abscesses that occur under the graft. This prevents further floating of the graft from the bed and large grafts can thus be saved.

It may be difficult to do a dressing where gross contamination is present. Pararesined gauze mesh can be sutured over the top of the graft when it is applied under fair tension. Later if one wants to open a small abscess in the bed of the graft, it is merely necessary to soak off the top dressing and the graft is not lifted from its blood supply. Dressing these contaminated grafted patients early prevents much of the maceration and breaking down around the edges of the graft. The saline bath is of great help here.

One believes that all raw areas should be covered at the initial operation if possible with free skin grafts and, if necessary, to rotate flaps over the defects. This prevents a lot of wound infection in the postoperative period and shortens the patient's disability considerably.

As far as the exposed bone cavities are concerned, the use of free skin grafts in them has been a great help. We have moved flaps over bone cavities early and in some cases have inserted cancellous bone chips at that time. These were done more or less for investigation, and it was quite remarkable how well healing took place without difficulty by covering with a flap, cleaning out the cavity and putting in cancellous bone chips.

I do think it is safer, however, to graft the cavity first and clean up all the infection. A flap covering may then be applied later and the cavity filled with cancellous bone chips. In the jaw or places with good blood supply one can do the other procedure in selected cases and save the patient one stage.

DONALD M. GLOVER (Cleveland, Ohio): The speakers have called attention to the fact that these organisms are primarily of nuisance value. I think that is essentially true. However, it is a fact that pyocyaneus infection particularly may interfere with the perfection of the skin graft, especially around the margins.

We had a rather long, concentrated course in these organisms when operating a general hospital in New Guinea, where, because of the constant moisture of the skin, these contaminators were almost universally present on the skin and in wounds also. Of course, the organisms do not grow in a dry field, so as long as the dressing is completely dry these organisms practically will not grow.

I think it is worth mentioning that these infections are completely controlled by an effective hypochlorite solution dressing. In fact we used the presence of any green stain as evidence that our Dakin's dressings were not being properly applied.

We usually found that, particularly while working in the tropics, if we continued Dakin's dressings directly over the graft after twenty-four hours and kept them wet with Dakin's solution, these minor contaminators were completely eliminated and the perfection of the graft was maintained. If the dressing can be kept completely dry throughout, however, it is not necessary to use Dakin's solution.

R. ARNOLD GRISWOLD (Louisville, Ky.): A great many of us, since the days of sulfas and penicillin, have been impressed by the fact that our gram-negative infections got along better even though we know that these drugs do not act predominately on gram-negative organisms. That is one point which has been brought out, but I should like to sound a warning to those of you who do not have as careful bacteriologic control as Drs. Gerrie and Ackman.

If you take a primary smear from a contaminated wound or from an appendiceal abscess, you will find it loaded with gram-positive as well as gram-negative organisms. However, if it is cultured on ordinary laboratory culture media by an ordinary hospital technician, you will get a bacteriologic report of colon bacillus or proteus or pyocyaneus. The reason for this is that the gram-positive organisms have been overgrown in the culture media by the gram-negative organisms. Unless you control the gram-positive organisms in the wound, you are going to have invasive infection even though the bacteriologic report mentions gram-negative organisms.

The bacteriology which has been done on the cases reported this morning has been very careful, and they knew what organisms they were dealing with; but in the ordinary hospital laboratory bacteriologic report we do not know accurately what organisms we are dealing with, and a report of gram-negative bacteria simply means that the harmless gram-negative pathogens (if you wish to call them that) have overgrown the harmful gram-positive pathogens in the culture media.

LATE JOINT CHANGES AS A RESULT OF INTERNAL DERANGEMENTS OF THE KNEE*

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AN important reason for correction of internal derangement of the knee joints not frequently enough stressed is the late changes that follow the initial damage. Such changes may be obscure or relatively undeveloped at the time when the derangement is first recognized and treated. These late changes at times are much more important than the immediate disabling defects. In order to understand these changes it is necessary to point out (1) the vulnerability of articular cartilage to trauma, (2) the relatively poor power of the cartilage on the articular surface of a joint to repair itself and (3) the inevitable result of the two preceding facts, that is, an irreparable damage which often is present after existence of an internal derangement for any considerable period.

By internal derangements is meant almost any condition affecting the articular surfaces or stability of the knee, whether it be by trauma, by disease or by neoplasm. Any loose or partially detached body which may impinge on the articular surfaces or be caught between any of the articular surfaces of the joint leaves its toll of damage to those surfaces. If the locking is between weight-bearing surfaces during the act of weight-bearing or between joint surfaces during action of muscles or movement, the damage is that much more severe. Then, too, if the loose body is firm and hard, more damage is done than by a soft cartilaginous structure like a meniscus.

Once a joint surface has become damaged or roughened its contiguous surface becomes subject to erosion during motion by the roughened area opposite it and wear and tear begins. One often sees direct evidence of this in joints opened for exploration and treatment of various sorts of internal derangement. I have been particularly interested in these observations. In order to record them more accurately, I frequently asked our photographic department to take colored photographs of knee joints opened at operation.* These pictures show the damage which may be inflicted on the joint surfaces of the knee by various types of internal derangement.

These changes are insidious in onset and slow in development so that it may take years for any serious demonstrable changes to come to light or to develop to the point at which they may produce symptoms. Patients may hesitate to see a physician because of the mildness of the symptoms produced. Likewise, the physician may be inclined to minimize the patient's complaint and unless he carries out a very careful examination he may miss some important diagnostic points. Beside a routine physical examination of the knee, with careful check for traces of swelling, effusion, atrophy, instability, tenderness and deformity, roentgenograms of several types should be made. These should include anteroposterior and lateral roentgenograms carefully taken as to position of the knee and direction of the rays, intercondylar notch roentgenograms made with the knee in flexion and the rays projected through the intercondylar notch and special patellar roentgenograms to demonstrate the contours of the patellofemoral joint and the relation of its surfaces. By these many irregularities of joint surface contours and relationships may be detected.

VARIOUS CONDITIONS WHICH CAUSE CHANGES

Torn Menisci. Late changes following this type of injury are of two kinds: those changes due to damage to the articular surfaces from the repeated lockings before surgical removal of the menisci and those changes secondary to removal of the menisci. Some have written of the latter changes and pointed out their occurrence but in my experience such changes are rarely as marked as the changes might have

* Dr. Ghormley showed colored pictures at this point which are not included in this publication.

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been had no semilunar cartilage been removed when it was indicated. In most instances a minute degree of thinning of the joint space on the side of the affected cartilage will be noted. In my experience this is of little importance if the damaging element has been removed, but if the damaging element is allowed to remain in the knee for a long enough time, serious changes do take place. Or if complete removal of that portion of a cartilage which is locking is carried out, further damage may be rendered to the joint surface.

Cysts of semilunar cartilages may also be the cause of lasting damage to the joint surface. In their early stage of formation while still small cysts they cause very little change, but as they become enlarged and encroach on the joint space some erosion of the articular surfaces occurs. This is variable in amount and is directly proportional to the size of the cyst and to its disturbance of the joint surface relationships.

Osteochondritis Dissecans. Osteochondritis dissecans has long been recognized as a cause of internal derangement of joints, particularly the knee joint. The amount of damage in such a joint depends on whether the segment of bone and cartilage has become loose in the joint and on the duration of time over which lockings have been repeated. The joint surface may be fairly intact in early cases, particularly if the patient is adolescent. In these cases a minimal amount of erosion takes place. As the fragment leaves its bed and migrates through the joint the erosion continues as the result of two factors: (1) the loose body itself locking and damaging the articular surfaces with each locking and (2) the erosion due to the irregularity of the joint surface at the site of origin of the loose body. If locking goes on over many years, fairly extensive damage to the articular surfaces will take place—damage which is irreparable by any method now known.

Synovial Chondromatosis. Synovial chondromatosis is another cause for the formation of loose bodies within joints. The cause of this complication is presumed to be a metaplasia of the synovial membrane and particularly of that portion of it bordering on the articular surfaces of the joint into a benign type of neoplastic tissue. The loose bodies vary in size from tiny cartilaginous bodies to large bodies, 1 to 2 cm. in diameter, composed of cartilage and bone. Frequent lockings are often noted and in these cases repeated damage to the articular surface occurs.

Chondromalacia of the Patella. This condition has fairly recently come into the category of recognized clinical entities. According to Cox, the condition was first described by Büdinger in 1908. Cox also described the gross pathologic changes noted at operation as follows: "(1) Softening, irregularity in contour and fissure formation in the articular cartilage of the patella; (2) yellowish discoloration of the articular cartilage of the femoral condyle on the anteromedial aspect; (3) similar changes in the articular cartilage of the femoral condyle on its anteromedial aspect; (4) thickening, hyperaemia, and villous degeneration of the synovium, usually confined to the suprapatellar pouch region and anterior compartment of the knee joint; (5) increase in the amount of joint fluid, usually clear yellow in color with normal cell count, or slight increase in polymorphonuclear cells; (6) pannus formation at the edges of the articular cartilage of the patella and femoral condyles."

All degrees of destruction of the articular cartilage of the patella have been noted. In milder cases pain is minimal and is noted on flexion of the knee and particularly on extension of the knee as in the act of stair climbing. In more advanced cases symptoms suggestive of locking are noted as the patella glides across the roughened femoral surface of the patellofemoral joint or as marginal spurs on these two surfaces impinge on each other. In more advanced cases patellectomy is indicated. In milder cases the roughened surface of the patella may be smoothed off with some improvement in the symptoms.

This condition is often seen as a complication in cases of recurring dislocation of the patella. In older cases the changes often reach an advanced stage with almost complete destruction of the articular surfaces of the patellofemoral joint.

Synovitis of the Knee. Several types of synovitis of the knee joint are now recognized, such as: Traumatic, acute, with or without hemarthrosis; chronic, as a complication of traumatic arthritis; infectious, due to various types of infecting micro-organisms such as tuberculosis, brucellosis and so forth; rheumatoid, intermittent hydrarthrosis; secondary to tumors as xanthomas, hemangiomas and synoviomas, and hemophilic.

Any of these types of synovitis may leave some damage to the joint surface. While it often is minimal in more prolonged cases, the damage may be severe enough to produce changes in the articular surfaces which will lead to permanent defects in the joint surface and to traumatic arthritis.

Fractures. Various fractures about the knee joint are a frequent source of damage to the articular surfaces which may become potentially symptomatic.

Fractures of the patella, fractures of the spine of the tibia and fractures of the tibial plateau are all intra-articular and may leave irregularities which can produce symptoms later on in life. The long-continued wear and tear on a knee joint in a leg in which bowleg or knock knee has been caused by a fracture will lead to traumatic arthritis in a large number of cases.

In these cases not only is there a direct trauma to the articular cartilage at the time of the injury but the stresses and strains on the joint surface due to abnormally directed forces in the malposed joint produce further changes. These are often insidious and slow in their development so that it may be years before any symptoms develop. The amount of damage to the articular surface of a joint adjacent to the fracture of a long bone has never been stressed. It is, of course, a difficult thing to evaluate unless there is occasion to explore such a joint shortly after the injury. I believe, however, that much more damage than is often recognized may be inflicted on the articular surfaces of such a joint as a result of the forces which produce the fracture, such forces being transmitted through the long bone to the articular surface with resulting trauma to the articular cartilage.

Torn Ligaments. Another source of abnormal wear and tear on the joint surfaces is the chronic relaxation of ligaments such as torn cruciate ligaments or tibial or fibular collateral ligaments. The most serious lesions of these ligaments are found as complications of chronic tears of the anterior cruciate ligament. In this condition an anteroposterior instability of the knee joint develops which usually leads to changes in the articular cartilages such as I have previously described. If the thigh muscles, particularly the quadriceps mechanism, are sufficiently well developed, these articular changes will be delayed or minimized in their extent.

CONCLUSION

I have discussed briefly some of the results to be expected as late changes in joints which are the site of internal derangements of various sorts. Many of these may be minimized or prevented by early removal of loose bodies, torn cartilages and other damaging structures. In other cases synovectomy may be necessary to relieve the condition. In many cases, however, much can be done to prevent the damaging development by advising the patient of his condition, by showing him how to develop muscular stability of the joint by means of exercises and by teaching him to avoid the more strenuous activities such as sports, hill climbing and stair climbing. Patients should also be taught to avoid excess weight, a very important factor in many cases. By such means the serious late changes can be minimized in their effect.

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DISCUSSION

Edgar L. Gilcreest (San Francisco, Calif.): Patients with lesions of the knee joint have remissions when the swelling and pain disappear for awhile; they are lulled into lethargy and want to postpone arthrotomy.

That is the time when the surgeon should emphasize that the patient is only putting off the evil day and that later, when he does have the symptoms that will cause him to urge the surgeon to operate upon him, he will never reach full recovery. Of course, he will believe that the operation failed to benefit him very much when the delay has been due either to the surgeon failing to make it clear to the patient why he should have the operation performed early before the degenerative changes occur, or the patient just simply will not take his advice.

It is interesting to note the extensive degenerative changes that take place in the knee joint and when we remember that the knee joint is the next to the lowest joint in the human body, always subject to stress and strain as the patient gets older and heavier, these degenerative changes will increase and even after the operation is performed

and if they have occurred they will continue to increase.

I think we should make it clear to the patient that as he gets older he must remember that he is partially a cripple, his knee joint will always give him trouble, he must expect it and not be disappointed; therefore, his job is to try to prevent damaging that knee joint still more by often wearing a crepe bandage or an elastic bandage. He must know how to put it on so he does not get it too tight. He should be taught how to rehabilitate his quadriceps muscles which always undergo great atrophy after some of these operations; often the surgeon does a cleancut operation but fails to tell the patient how to exercise his quadriceps muscles. That is a job that should be done for one-half hour every way. I think we often have failed to tell the patient after surgery about dozens of these little things, about how he can restore his knee and get a fairly satisfactory recovery.

We have learned this morning how important it is to perform an arthrotomy which can be done often under local anesthesia; we must see what has taken place there before it is too late and these advanced degenerative changes take places.

Wilbert Hersman McGaw (Cleveland, Ohio): In my experience with about 400 knee cases mostly during the war we made a study at one time of the patellar changes and found that just over 30 per cent of all of our patients with derangements of the knee showed some degree of chondrosis or osteochondrosis of the patella. I believe that no arthrotomy of the knee is complete until the articular surface of the patella has been examined. I think we could borrow a term from Murray and state that there is a definite "time element" in the development of arthritic changes resulting from internal derangements of the knee. At one time we happened to have on the ward three patients: one had a four-day old injury to a knee, another injury was four years old and the other was ten years old. All of these patients had a torn medial meniscus and we happened to have specimens of these various knees whose original injury varied so much in type. The first patient showed no arthritic changes in the joint at all. The second patient who had repeated attacks for four years showed beginning condylar lipping and thickened synovia while the patient with the ten-year old injury showed extensive lipping and softening of the patella, femur and tibia and marked thickening of the synovial membrane.

One can frequently tell within a few days by use of a pneumarthrogram whether or not the subject should be treated conservatively or if a meniscectomy should be performed before arthritis develops.

Paul B. Magnuson (Chicago, Ill.): I have been operating upon many patients with knee injuries over a period of twenty years, and until now I have never had to perform a patellectomy.

Some six or eight years ago I published an article on regeneration of cartilage around the knee joint. We tried to reproduce traumatic arthritis in dogs and we tried all sorts of experiments—putting foreign bodies in them, doing an osteotomy above the knee and putting them under cross strain, traumatizing the cartilage, stripping the cartilage, putting in pieces of bone, foreign bodies in the way of bone and also metal.

We had been working on this experiment for about a year and nothing had happened. The dogs were perfectly healthy; x-ray showed nothing. Examination of the dogs did not even show any swelling.

Finally I had an idea and I said to Dr. Horral, who was working on those animals with me, "You know, we both ought to have a neuropsychiatric examination. We have done all sorts of things to joints here to produce trauma, and we have never allowed these animals to have any trauma to their joints because they are all put back in their cages in the laboratory. Let's take some of these animals out to the farm, and I'll put them in long runways between the runways my dogs are in, and let them race and have a good time."

You would be surprised to see how fast traumatic arthritis will develop after you put real strain on it. The ones that developed it the most rapidly were not the ones who had foreign bodies in their joints but were the ones in which we had cut the internal lateral and the crucial ligaments and folded them back so they would not heal, therefore, there was nothing but skin holding the joint together on one side. These dogs could run just as fast as any of the other dogs as long as they kept on a straight line; I often say they ran like a destroyer and turned like a battleship because when they got to the end of the pen they slowed down and turned very carefully.

In spite of that the constant bumping caused by the relaxation or removal of the ligament and the instability of the joint in six months regularly and uniformly the dogs so treated showed exostosis around the joint that was typical of the exostoses in ordinary chronic hypertrophic arthritis. That does not mean we are talking about atrophic arthritis at all; that is a horse of another color. Just because it happens in the joint there is no reason for considering it in the same category.

In none of these cases have we removed the patella and in none of them have we done a synovectomy except in those in which the synovia was peppered with foreign bodies. In one case I remember taking out one foreign body which was attached to the upper end of the patella and I could not tell the difference, until after careful examination, between it and the patella because it was just as large as the patella.

This erosion does occur and it occurs from constant irritation, in my opinion, and it occurs more

frequently probably in obese, older women or athletes who have had a previous injury than it does in other classes of patients.

In our course of experiments we found that we could scoop out great pieces of cartilage and bone from the surface of the joint, even out of the weight-bearing surface of the joint, and it did not affect the joint at all. We were never able to produce any reaction in the joint by doing that, just removing a large piece from the middle of the joint, even out of the weight-bearing surface.

If that is so in the human, I can see no reason why we should take out the patella if there is any cartilage left at all. This erosion of the cartilage that occurs between the patella and the femur is probably the most common thing that occurs in the knee and it is easy to find on examination when a patient comes in complaining of pain in the knee; certainly we should never fail to sit in front of the patient who should be seated on a table and grind the patella up and down longitudinally against the condyle. You can feel the crepitation and you can cause pain.

That condition is usually found in a patient who appears early but the condition does not show up in the x-ray. I think a good many times it is confused with foreign bodies in the knee because there is locking, the same as though there were an actual foreign body in the knee. What happens? It seems to me it is very easy to explain. The patient straightens his knee; he gets it into almost full extension, lacking probably 15 degrees; the last 15 degrees of extension pulls the patella tight down against that eroded surface and produces a grinding and to me it is a thing exactly like a rough bearing. You get to the point at which the two rough surfaces catch each other and they cause sudden sharp pain. The patient thinks he cannot move his knee, but as soon as he shakes it around and takes the weight off the patella he can move it very easily.

In dozens of these cases we have not removed the patella. We have narrowed the patella when it was wide, and sometimes we have shaved the cartilage down to bare and bleeding bone, in some spots in the same joint. We always shave it so it will form tracks.

In these cases with this type of operation—and I am not talking about the ones that need arthrodesis—if you shave them longitudinally parallel to the motion of the joint, those tracks of cartilage left will act as tracks and the joint will move with them very well. You can hollow out the intercondylar notch where the patella comes in contact and you can cut out the patella so that only the sides contact and those knees will work and go on working.

I may be a little foolish about removing the patella because I have no doubt it gives very satisfactory results in some cases, but the patients that I have seen have caused me to believe they were not as satisfactory as they would have been if they had had the leverage of the patella through which the quadriceps muscle could apply as power to the head of the tibia.

I have shaved some of these joints down in the last few years until I feared they might not work. Dr. Gilcreest spoke about keeping the quadriceps exercised. It is not a question of keeping it exercised, it is a question of making the patient keep it exercised and in doing that you must put your patient in a position and in suspension so that he can exercise it without its giving him too much pain; then you must see that he does it until he learns how and the learning how should start the day after the operation.

I expect these patients to have 45 degrees of motion in eight days after the operation, and I expect them to get on both feet and walk eight days after the operation. It is not difficult to do if you show the patient how to do it. Get him out of bed; first, teach him how to stand. It does not hurt the knee when he stands with his knees straight. The thing that hurts is throwing weight on the joint with the knee bent. Teach him how to stand, support him and do not let him bend forward; have the knees straight, hips straight, chest up and head up. I never give them crutches, never; some of them may have canes, but those canes are made the right length for that patient to use in walking without stooping forward. Give him enough support.

Then, after you have him standing, stand behind him and with his elbows bent, take firm hold of him at the elbows and walk with him, seeing that when he puts that operated leg forward he gets the knee straight before he puts his weight on it. In three or four days these people are out of the hospital.

I remember Dr. Cubbins came to see one of these procedures. This operation was on a doctor, too. Dr. Ghormley showed us several such cases.

When I was about two-thirds of the way through the housecleaning of the knee, Dr. Cubbins asked if we expected that fellow ever to use the knee again. In a few days Dr. Cubbins visited the patient and the man was exercising his quadriceps, not fifteen or thirty minutes in twenty-four hours but three or four minutes every half hour as long as he was awake. On the eighth day he was up and walking down the hall with me. On the tenth day Dr. Cubbins came in and the man met him at the elevator with his bag in hand on his way home. That man was seventy-two years old.

That is not uncommon. You can do many of these things with these joints without taking out the patella and without doing a synovectomy. I am not talking about rheumatoid arthritis or the type of synovia that is peppered with foreign bodies; I am talking about hypertrophic arthritis. I cannot tell the difference between that and

trauma, and I think trauma has a very definite bearing on it; certainly cross strain, overstrain or faulty weight-bearing of any kind will produce it.

RALPH GHORMLEY (closing): I want to thank the discussers for their very enlightening remarks.

I appreciate Dr. Gilcreest's comments. I should have stressed, of course, the importance of exercising the quadriceps on which I think we all agree. As you all know it is sometimes very difficult for the patient to learn to do a quadriceps exercise properly, and the manner in which the exercise is done has to be checked carefully and correct performance insisted upon.

Dr. McGaw mentioned the time element. I mentioned the fact that internal derangements are sometimes long in developing. One has to foresee the possibilities in outlining the immediate treatment for traumatic arthritis of the knee in order to prevent these late changes. I think Dr. McGaw's ability with pneumograms is marvelous. I saw his exhibit at the Academy of Orthopedic Surgeons last winter and it was very enlightening. By the use of pneumograms and several different types of roentgenographic views of knees which I showed you I think we can pretty well diagnose internal derangements of the knees nowadays.

I am sorry Dr. Magnuson disagrees with me on the question of patellectomy. We have had patients on whom we have performed this operation who returned for the same operation on the other knee. It is significant that they obtain a lot of relief from it. I still believe that many of these patients are benefitted by patellectomy. We use synovectomy only in cases of chondromatosis of the synovial membrane, and occasionally, of advanced rheumatoid arthritis.

We remove loose bodies and bits of cartilage and attempt to restore the contours of the knee to as near a normal shape as possible; we then insist upon a rigid regimen of rehabilitation in order to get the knee of the patient back to as nearly normal as possible. The patients have damaged knees in most of these cases. Their lives will be bound by certain restrictions which might have been prevented if the diagnosis had been made early.

I do not believe anyone should hesitate to do a biopsy and be sure of the diagnosis if the knee is swollen persistently for two or three months and if a reasonable amount of treatment has been given and failure to restore that knee to normal has been noted. Occasionally one finds hemangiomas, xanthomas or synoviomas, in which case the knee never could be restored to normal without surgical treatment. Operation is necessary in many cases to get a proper start toward recovery.

SOME USES OF UNDETACHED OMENTUM IN SURGERY

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IT has long been a matter of common knowledge among surgeons familiar with bowel surgery that when anastomosis of the large bowel is made in proximity to omentum, the results are definitely superior to those in which the same procedure has been carried out in an abdominal cavity essentially devoid of omentum. In other words, when the omentum is scant or absent, the patient's outlook is not nearly as good and the mortality incidence not inconsiderable.

Senn foresaw the surgical value of omentum as repair material and made use of it in experimental surgery on several dogs. His reported results were gratifying. Accordingly, he later made use of omentum in several of his clinical cases.

Thompson and Pollock used omentum in various types of surgery performed on sixty dogs. Each case was checked by autopsy or by re-operation. Most of the grafts were applied to freshly lacerated or scarified surfaces. The results were most satisfactory. In some cases the omentum was taken from the animal undergoing operation at the time; in other cases the omentum was taken from other animals (dogs) and immediately used. In still other cases the omentum was preserved for several days before using; in still others the omentum had been preserved for as long as two weeks.

In some cases omentum was applied to freshly scarified bowel with immediate take and cessation of bleeding. In other cases omentum was wrapped around the suture line after end-to-end anastomosis between the divided ends of the esophagus. Again, the amputated partially closed end of a bronchial stump was covered over with omentum. In other cases omentum was applied to injured blood vessels of major size with excellent results in nearly all cases. The use of homologous grafts apparently gave equally satisfactory results as compared with the results obtained by the use of autogenous grafts. Likewise, grafts that had been preserved in sterile saline or Ringer's solution and stored in the icebox anywhere from twenty-four hours to one or two weeks took well and the results were satisfactory. These grafts were applied to pleura, the cut surface and edge of the lung, the bronchus, esophagus, aorta and vena cava. They became adherent and viable in 95 per cent of cases. Four failed to take. Three of these were autogenous; one was homologous. In two of the failures the graft was not sutured in place but was anchored with plasma glue (probably not a fair method due to the constant movement of the lung). Thompson further states that the possible uses of free omental grafts in the thorax are: hemostatic effect, reenforcement of suture lines and replacement of defects.

Thompson mentions the fact that in 1906 Lowe reported controlling hemorrhage of the liver with free omental grafts and says, "The ability of an omental graft to control a spurting branch of the pulmonary artery by simple application with gentle pressure for three minutes is very dramatic." He suggests also the use of the omentum in controlling bleeding from the spleen and also the kidney. The ability of a free omental graft to adhere and become viable over a suture line, thereby re-enforcing and adding an extra layer of tissue, probably is the outstanding value of the graft. The clinical application of this property in the closure of bronchial stumps and around an end-to-end anastomosis of the esophagus would seem to have great value.

O'Shaughnessy, in his discussion of surgery of the heart with reference to coronary disease, describes the experimental work that he and his associates of the Lambeth Cardiovascular Clinic carried out in regard to patients suffering from coronary disease and other gross cardiac defects. They first began their work by doing experimental procedures on racing greyhounds. They call attention to the well known fact that these dogs are subject to heart disease, frequently having to be put off the track for that reason. A number of these dogs underwent the operation of implantation of omentum into the pericardial sac and the attachment of this

omentum by sutures to the heart itself. They found that the dogs not only tolerated the surgery well but in many instances were enabled in due course to return to the track and to make a good record at their previous occupation. They based the type of operation on the fact that certain cases of coronary disease that were later complicated by pericarditis showed definite improvement and in some cases clinical recovery. Still later they carried out these operations in a series of clinical cases.

O'Shaughnessy and his associates, Dr. Daniel Davies and Dr. H. E. Mansell, with the collaboration of Lord Dawson of Penn, performed twenty operations for cardiorevascularization at the Cardiovascular Clinic at Lambeth. These operations were reported in 1938. Fifteen of the patients were suffering from angina pectoris, five of whom died, one on the table, another from uremia three months after operation and three from heart failure two months after operation. The survivors who had been submitted to the full (complete) graft operation made such progress that those who were bedridden at the time became active again, and those who were unable to work were able to resume their employment. There were five patients in this group who had symptoms of cardiac ischemia other than angina and in this entire group there was not a single death caused by operation. In the treatment of coronary disease the main purpose of the graft is to supply blood for the main local circulation. The object in brief is to reproduce by operation the situation which sometimes arises in nature when a pedunculated subserous fibroid suffers partial necrosis because of an inadequate blood supply going through a narrow pedicle. Omentum adheres to the affected area and not only arrests the process but provides a collateral circulation adequate for increased growth in the size of the tumor.

The omental graft serves to supplement the natural collateral vessels in the mediastinum and to give them access to the heart. It has been suggested by Beck (1936) that the graft may serve as a bridge between the right and left coronary vessels. In the operation of cardio-omentopexy the graft is always attached in the region of the apex so that it may form attachments partly in territory supplied by the left coronary artery and partly in territory belonging to the right coronary artery.

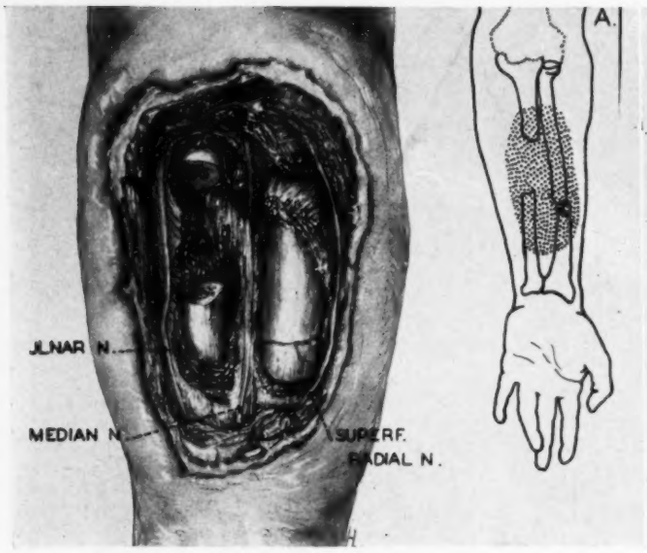
The re-enforcement of stomach and bowel perforation repairs with omentum is a time honored procedure.

FIG. 1. Compound fracture of forearm showing hiatus in ulna and fracture of radius that has been reduced and is being held in position by a Kirschner wire.

Following is a report of a case of severely lacerated wound of the forearm incidental to a compound, comminuted fracture of the radius and ulna in which undetached omentum was used as a graft.

CASE REPORT

J. H., a thirty-four year old white male, entered the Charleston General Hospital on October 4, 1945, with a compound, comminuted fracture involving both bones of the left forearm. A considerable portion of the ulna had been torn away. There had been extensive destruction and loss of soft tissue. An attempt had been made to cover the large open wound with an immediate skin transplant. When I first saw him several days later, it was obvious that the attempted skin transplant had failed to serve its purpose. The wound was grossly contaminated; an abundance



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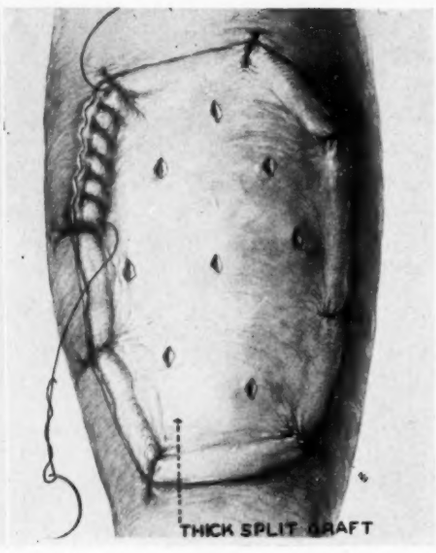

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FIG. 2. Drawing indicating some of the exposed nerve trunks.
FIG. 3. Omental implant after it had been freed from its abdominal attachments and covered over with a split thickness graft.

of green pus was present. There had been severe damage to the flexor tendons and muscles. The radial, ulnar, median and several smaller exposed nerve branches appeared to be intact likewise, the radial artery. The ulnar artery had been divided but was not bleeding. The fracture of the radius was reduced a few hours after admission, alignment being maintained by the intramedullary insertion of a Kirschner wire.

The patient had but little control of the thumb and index finger. It was believed that there was great danger of loss of function of the hand and that radical use of omentum might be the means of saving the situation.

Operation was performed on October 8, 1945, by the author. An incision was made in the upper portion of the epigastrium and extended downward for about 2¾ inches. It was noted that there was a non-fatty type of omentum of generous proportions. The hiatus in the forearm was so great in size that practically the entire omentum was required to fill it. The transplanted omentum was held in place by a few interrupted sutures plus a vaseline gauze mechanic's waste, pressure type of dressing. Apparently, rapid union of the omentum took place.

The change that occurred in the condition of the injured forearm was most striking. The evidence of infection in the arm rapidly disappeared. The full function of the thumb and fingers gradually returned.

At the end of ten days, previous to dividing the base of the omental implant, the stump of this graft was partially clamped off each day for ten days, the clamp being left in place for a longer period each time. Following this (November 10, 1945), a split thickness skin graft was applied over the omental implant in the left forearm, also over the omental stump that had been amputated flush with the abdominal wall. The graft over the omental stump in the abdominal wall did not take well and ultimately the stump was mobilized, peritonized and returned to the abdominal cavity. The split thickness graft over the omental implant in the forearm was only partially successful; likewise the application of pinch grafts approximately one month later was not entirely satisfactory; the omental graft later on was successfully covered by a skin flap from the patient's chest.

Comment. Previous to the placing of the omental implant into the wound of the left forearm, the condition of the wound was such that the forearm was in grave danger. The apparent prospects were that of a permanently crippled hand. The omental graft promptly overcame the infection and saved numerous exposed tendons and nerve trunks; in other words, it saved the patient from becoming handicapped for life by a relatively useless arm.

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DISCUSSION

WALTER G. STUCK (San Antonio, Tex.): I presume I was asked to discuss this paper because of

my interest in the transplantation of muscle flaps into the hip joint in an effort to provide an accessory circulation. Of course, I know nothing about abdominal surgery so I cannot give an expert opinion on the advisability of bringing a flap of omentum out through the abdominal wall and attaching it to a cutaneous defect in the forearm.

In addition to the work of O'Shaughnessy, which Dr. Cannaday mentioned, Friedbacher and Morison transplanted flaps of omentum to provide accessory circulation elsewhere. It stands to reason that a flap of this sort would be more vascular than a flap of skin that had been lifted off the front of the abdomen. I know that muscle flaps can be transplanted successfully into the heart wall, the cerebral cortex and to the medulla of bone. Whether the use of omental flaps will achieve the same results or not, I do not know; but in this case Dr. Cannaday has demonstrated that the flap will unite to the forearm soft tissues even in the presence of infection.

JOHN E. CANNADAY (closing): I have nothing further to add except that since the wound in the arm, when I first saw it, was reeking with green pus infection, I believed I was dealing with a serious emergency and one that would have to be dealt with very radically if the patient's arm or its function were to be saved.

It occurred to me at the time that the use of an omental transplant would be the only means by which this could be done. I had the impression that omentum was capable of taking care of almost any kind of local infection if it acqured a sufficient hold on the infected tissue.

TWENTY-FIVE EASY WAYS OF GETTING INTO TROUBLE IN THE CARE OF FRACTURES*

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THE modern development of fracture treatment has been continuous in point of time with the active life of the present author. The conferring of a baronetcy upon William Arbuthnot Lane in 1913 gave official recognition to the renaissance of fracture care. During the first stage of the war (1914–1918) definite advances were made, more especially by popularization among surgeons in the British, American and Canadian armies of the methods of Owen Thomas through the protagonism of Sir Robert Jones. Since 1918 the frequency with which monographs and textbooks have been published bears witness to the fact that the problems of fracture treatment have become more and more important both in the medical curriculum and in the attention of both general and orthopedic surgeons.

In his Presidential Address before The American Surgical Association in 1946, Dr. William Darrach chose as his title "Treatment of Fractures."[1] He began his address with the following sentence: "A fracture patient i an individual whose normal activities, both vocational and avocational, have been interrupted by an injury . . . The damage is rarely limited to the bone. Associated soft-part injuries are often of greater importance and need more careful attention than the fracture itself." He states further in his summary: "The object of treatment is to return the individual to a normal state as completely and as rapidly as possible . . . In planning treatment each case must be studied as an individual problem and all the factors evaluated. Success will depend more on a correct understanding of the problem and a wise plan of action than on the methods by which that plan is carried out."

In the preparation of this address I believed that the purposes indicated by Dr. Darrach might well be studied through a consideration of the pitfalls which are likely to be met with in the treatment of these patients. If the title is deemed to be facetious and perhaps provocative, these qualities are not accidental. The twenty-five errors which are touched upon do not exhaust the possibilities. I believe, however, that were these avoided, the results obtained by surgeons throughout the world would be improved.

I shall mention only in passing the benefits of protective splinting in the initial transportation of the injured. Omissions in this initial stage of care may institute a train of stubborn troubles but are largely beyond the direct control of the attending surgeon. There remains a sufficient number of ways of courting trouble once the patient is in a position to come under definitive care. Errors can be committed before, during or after the definitive treatment of the injury itself. The following are nine ways of getting into trouble before treatment of the fracture is actually instituted.

ERRORS MADE BEFORE TREATMENT OF THE FRACTURE

The first and most serious error is *failure to assess the severity of associated traumatic shock.* A clinical analysis of the vital signs must precede the local and general physical examination. Blood pressure estimation is of major importance in fractures of ribs or skull and in cases of multiple fractures which involve the major bones. Failure to be fully aware of existent or impending shock is of especial importance when a major operative procedure is on the point of being undertaken. However, this error may be even more dangerous when no immediate treatment is planned, as is illustrated by the following case: A young man, age twenty-two, was thrown from a motor cycle, receiving a blow which resulted in a fracture of the pelvis. (Fig. 1.) The fracture was diagnosed quickly but there was no skin wound. Accordingly the available surgeon turned his attention

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to the young man's companion who had a severe compound shoulder wound. While the latter patient was being operated upon, our man with the fractured pelvis slipped into a profound state of shock, became pulseless and without recordable blood pressure. A very large hematoma was discovered over the fracture site and massive transfusion was required, which fortunately was effective.

Our second error is only slightly less critical. It consists in *failure to diagnose concealed non-bony injuries*. The young surgeon in training must be taught to miss nothing by developing a clinical approach to the injured patient which reveals the most while disturbing the patient least. There is no substitution for acuity of observation. Fractures of ribs, spine and pelvis may demand that the urinary bladder be catheterized. A small head wound may demand a neurologic examination. The chest and abdomen may contain damaged viscera. Worthy is the surgeon who diagnoses a traumatic hemathorax, pneumothorax or a ruptured diaphragm through the medium of eye, hand and ear. The familiar conjunction of alcohol with a fall lays a special trap for the unwary. The flaccid patient may be inebriated indeed but he may also be incapable of drawing attention to his broken neck. It is characteristic of trauma to transcend the boundaries of our professional subspecialties.

Third, stands the error of *failing to diagnose all concomitant fractures* and their complications. Even in the conscious patient diagnosis demands not only thorough examination of all bones and joints but also repeated questioning to exclude painful lesions which may appear to the patient to be of minor importance at the time. The integrity of trunk nerves and major arteries must be checked, bearing in mind the fractures most commonly associated with nerve injury. For example, a common minor, associated injury is a fracture of the upper end of the fibula, but simultaneous injury to the common peroneal nerve may lead to prolonged disability and possibly serious legal consequences if its presence goes unrecorded. In the event of either vascular or nerve injury being demonstrable when a case is first seen, it is a wise precaution for the practitioner or surgeon in charge to obtain the help of a fellow practitioner in order that protection may be available should criticism be encountered later.

FIG. 1. Simple fracture of the pelvis which led to formation of a hematoma so extensive as to threaten life.

Examination for concomitant fractures is facilitated if the mechanism of the more obvious injury is known. For instance, falls on the feet may fracture or dislocate any part of the weight-bearing skeleton, while falls on the hand may similarily disrupt any part of the upper extremity. Damage to the supraspinatus tendon not uncommonly accompanies a Colles' fracture. Diagnosis in the patient rendered unconscious by a head injury requires added care and thoroughness.

Our fourth error is *failure to obtain adequate preoperative x-ray pbotographs*. The purposes of this initial x-ray study are as follows: (1) To exclude bony injury in cases in which by clinical examination the possibility of fracture is suspected but not proven; (2) to determine the exact type of injury with special reference to information which will permit the mechanism of production to be inferred; (3) in order that prognosis may be indicated to the patient and to other interested parties; (4) for purposes of permanent record, especially in cases in which it is clearly impossible to avoid a certain degree of permanent incapacity; (5) to avoid oversight of concomitant fractures, such as the carpal scaphoid in the case of fracture of the head of the radius or compression fracture of a lumbar body associated with fracture of the os calcis. In order to be "adequate," x-rays must include at times a number of oblique views in addition to true anteroposterior and lateral projections. Fractures of the carpus, especially

of the triquetrum, may be overlooked unless oblique views are taken; while multiple films of the fractured os calcis are required if all possible help is to be obtained from the radiologist.

If clinical signs suggest fracture but x-ray examination fails to reveal a solution of continuity of the bone, x-ray examination should be repeated after sufficient time has elapsed to permit bone absorption at the site of the fracture. In the interval trouble will be avoided if such cases are treated as though fractures were proven to be present. Perhaps the most important injuries of this sort which are likely to be overlooked in early x-rays are those of the carpal scaphoid and of the lumbar bodies, the latter being the type of case to which the term Kümmell's disease is applied.

The fifth easy way to court trouble is by simple *failure to identify films*. Two young men were skiing in the famous hills of our Laurentians on a recent occasion and within a few minutes of one another each sustained an injury to a lower extremity. They were admitted to the small hospital available for such cases where x-ray examinations were made. The patient who came to my attention was placed in a plaster cast from the toes to below the knee. He was presented with an x-ray film showing a trivial crack in the lateral malleolus of the external rotation type. He was instructed to walk and was placed upon the train for Montreal. Upon arrival at the Herbert Reddy Memorial Hospital in Montreal he complained bitterly of the difficulty which he had had in reaching the city. It appeared that the slightest movement in bed caused pain. X-ray examination was repeated which revealed fractures of both bones of the leg.

The victim of this mixing of x-ray pictures was paradoxically amused when the situation was explained to him. His amusement was due to the fact that the other young man, with the simple crack in the lateral malleolus, had been transported to Montreal by ambulance at a very substantial expense.

Failure to interpret x-ray photographs is our sixth cause of difficulty. Errors of this type are perhaps most easily made in the region of the carpus where the multiplicity of bones and joints makes the exact interpretation difficult, especially to the inexperienced. Mid-carpal and mid-tarsal dislocations may give very misleading x-ray appearances owing to superimposition of small faceted bones. In a case which came under our observation recently a displaced fragment of a fractured os magnum was mistaken for a portion of the scaphoid. The diagnosis was made of fracture of the scaphoid with wide separation of the fragments and on this diagnosis the scaphoid was excised. At operation the scaphoid was found to be fractured indeed but without displacement to the perturbation of all concerned.

Another group of cases in which x-ray interpretation is of first importance to treatment and prognosis is the broad group of pathologic fractures.

The seventh error is *failure to recognize the mechanism of production of the injury*. The patient's own account of the accident will often throw much light upon the mechanism and should be correlated with the preoperative x-ray films. For example, when the elderly lady is emphatic that her leg gave way and she fell and x-rays show an abduction fracture of the femoral neck, a good prognosis can be assured. Conversely, a fall on the hip with an adduction fracture results in a situation of greater severity and difficulty. In Smith's fracture at the wrist the primary pitfall of mistaking the lesion for a Colles' fracture is avoided if the mechanism is studied.[2] Tibial flexion or adduction injuries of the ankle joint are relatively uncommon, but it has been our experience that these fractures have been seen for serious deformity many months after injury, and usually as a result of failure to recognize the nature of the injury at the initial treatment. It is my experience that most fractures of the posterior malleolus of the tibia can be considered to be caused by an external rotation mechanism. If these injuries are immobilized with the ankle in forced internal rotation, a large number of open operations will be rendered unnecessary.

The eighth error is *inadequate records*. This applies particularly to the initial recording of primary injury to vessels and nerves. The record must be clear as to what lesions already existed at the moment the patient first came under one's care. One must bear in mind the frequent association of damage to the radial nerve and fractures of the humerus, of the common peroneal and the fractured head of the fibula, of the ulnar and fractures of the median epicondyle of the humerus. Less commonly seen are lesions of the circumflex nerve in shoulder injuries, and the rare but extremely

painful median nerve neuritis associated with Colles' fracture.[2] The record should contain a note on the state of the arterial pulsation in any injured extremity. It is the duty of every surgeon to avoid unwarranted criticism. In this connection failure to record the difficulties inherent in the individual case is to court trouble.

Before treatment is begun our ninth and final preoperative error is *failure to notify all concerned of the prognosis* which may be anticipated. The late Dr. J. M. Elder was the most impressive bedside teacher under whom it was my privilege to study. He was accustomed to state his views on this subject in the following terms: "Always bear in mind that your patient is but little interested in your diagnosis. He is somewhat more interested in the therapy employed since he will be more or less uncomfortable depending upon your decision in this regard. However, he is profoundly interested in your prognosis, both in so far as this refers to the eventual result, and more particularly to the length of time which will be required for such result to be obtained."

The patient, one should add, cannot be expected to comprehend the complications and delays which may confront him unless these are explained to him. The same notification must be given to all interested parties such as parents, guardians, insurance companies and compensation boards. It is especially important to indicate in advance the probable results of a particular injury when the end result is liable to be unfavorable. However, this approach can be of help even in minor trauma. For example, if one is careful to inform the mother of a child with a fractured clavicle that if all goes well a lump will appear over the fracture in three weeks' time, alarm on the part of the parent when the lump appears is replaced by a measure of delight.

Again, the parents of children suffering fractures of the lower end of the humerus should be advised of the possibility of a cubitus valgus developing late, with possible loss of function of the ulnar nerve. They should be told to report the development of any weakness of the hand. Similarly, late deformities and disabilities following epiphyseal injuries should be warned of in advance. The high risk to life of hip fractures in the aged should be mentioned to the patient's family.

ERRORS DURING ACTUAL TREATMENT OF FRACTURES

We are now in a position to begin our active treatment, having avoided nine easy ways of getting into trouble before treatment is even begun. Our tenth is *delay in fixation*. Such delay is difficult to excuse once the patient comes under our care. The Thomas splint resulted in a distinct decline in mortality from fractured femur when it was introduced during World War I. It is still the first fixation device for this type of injury. In the lower leg and ankle the pillow splint will give fixation while definitive treatment is being arranged and will also minimize swelling.[3] A folded newspaper with an aperture for the thumb will immobilize a Colles' fracture. It is obvious that delay in fixation may add further trauma to local soft tissues, but it is not always appreciated that this error is a potent cause of acute bone atrophy as is illustrated by the following case. Mrs. C. M., age fifty-three, suffered a Colles' fracture without displacement late in August, 1947. Her physician decided to omit fixation entirely in her case and simply placed the forearm in a sling. Nine weeks later she was referred to me with severe pain and swelling of wrist, hand and fingers, and loss of almost all movement. I applied a plaster at once and obtained the x-rays shown. (Figs. 2 and 3.) Acute bone atrophy was present in wrist, hand and fingers. The frequent finding of this lesion in fractures in which fixation is delayed has convinced me that the relationship is more than accidental.[4,5,6]

Eleventh is *delay in reduction*. In general it may be said that delay in reduction is of less importance than delay in fixation. However, in certain fractures delay in reduction may seriously jeopardize the ultimate result. Paramount among these is the supracondylar fracture of the humerus, followed by a variety of fractures about the ankle, wrist joints and fingers.

The majority of surgeons and practitioners appreciate the importance of our twelfth error which is *inadequate reduction*. In fact, this aspect of treatment is often overstressed to the neglect of other aspects. Nevertheless, it remains a general rule that the more perfect the anatomic reduction the shorter the period of total disability and the better the end result obtained. In reaching a decision as to whether

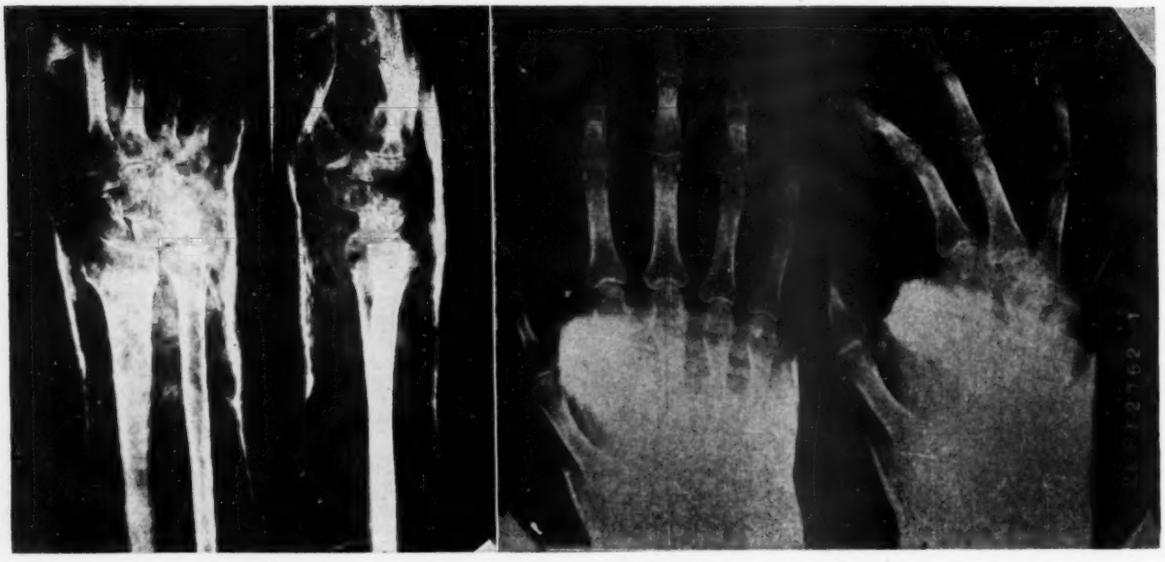

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FIG. 2. Case C. M. Acute bone atrophy following Colles' fracture of left wrist treated without fixation for nine weeks.

FIG. 3. Same case as in Figure 2 showing marked bone atrophy of phalanges of left hand.

one should endeavor to improve the reduction obtained at the first attempt, one must weigh the consequences of added trauma which always accompany repeated manipulations. The growing child and especially the newborn can compensate for degrees of displacement which would not be acceptable in the adult. Perhaps the most common and serious error occurring during attempts at reduction is distraction of the bone ends. This is an especially common cause of trouble in fractures of the shaft of the humerus, and in my opinion all reduction procedures involving heavy traction are to be avoided in this fracture.[7]

The thirteenth source of trouble is *undue roughness during reduction.* There is no practical method of measuring the forces exerted in the manipulation of the individual case. However, if every movement to which a fractured limb is subjected be decisive and purposefully planned, a minimum of added trauma to soft parts will be produced. It is important to bear in mind that the periosteal tube about the bone may be partially intact when reduction is started and should not be damaged further by rough handling. In fractures of the femoral shaft, for example, a thick strip of tendinous tissue forming the muscular insertions on the linea aspera may be torn. A tongue of this tissue may become interposed between the bone ends during distraction and non-union may result, as has been brought to my attention by Dr. R. R. Fitzgerald.

The unfavorable consequences of *repeated attempts at reduction* have been mentioned before but the matter deserves to be listed as our fourteenth cause of trouble. In my opinion it is the most important single cause of acute bone atrophy, especially in fractures in the neighborhood of joints. The two joints most frequently the site of repeated attempts at reduction, namely, the wrist and ankle, are precisely those areas in which acute bone atrophy is most frequently seen as a serious complication.[4,5,6] The following case is typical:

Miss M. G., age fifty-one years, fell on shipboard and suffered a Colles' fracture of the left wrist. An immediate attempt at reduction was carried out by the ship's surgeon and the forearm was fixed in splints. Reduction was again attempted under local anesthesia three days later upon arriving in port and a posterior plaster mould applied. Two weeks after injury a further attempt at reduction under general anesthesia was made and a heavily padded circular plaster bandage applied. The patient was seen by me eight days after the third attempt at reduction. Both active and passive movements were painful and fingers and hand were very swollen. She volunteered the information that prior to the third attempt at reduction the fingers had been freely movable and the

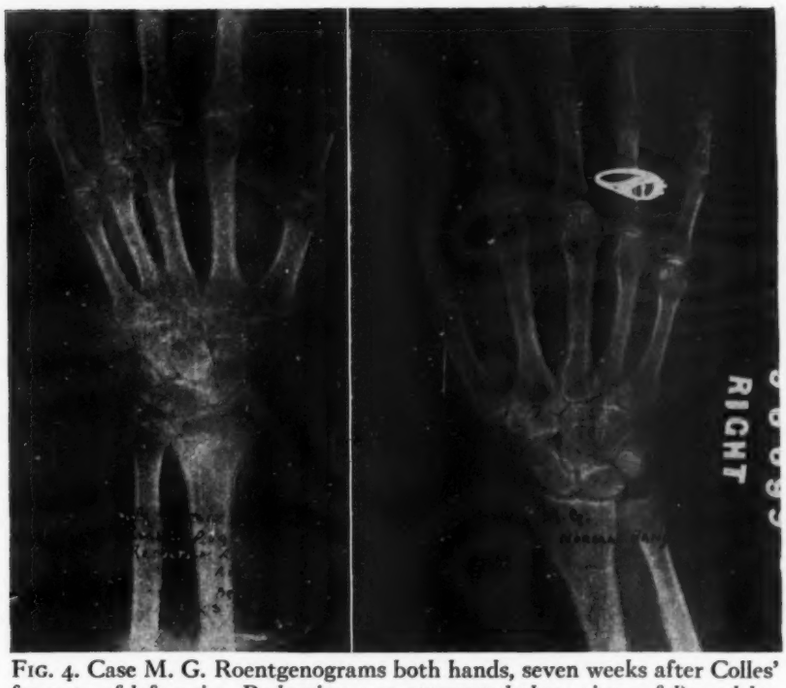

FIG. 4. Case M. G. Roentgenograms both hands, seven weeks after Colles' fracture of left wrist. Reduction was attempted three times, followed by development of acute bone atrophy.

hand relatively painless. Plaster was reapplied without padding but the pain increased and the limb became useless. X-ray examination seven weeks after injury showed well marked patchy bone atrophy to be present. (Fig. 4.) This atrophy involved the lower end of the radius and ulna and all the carpal bones, both extremities of the metacarpal bones and to a lesser extent the phalanges. The joint contours were distinctly shown. Union at the site of the fracture appeared to have progressed satisfactorily with but little displacement. Treatment consisted in the avoidance of any movements which caused even the slightest pain. However, many months were required before recalcification occurred. Functional recovery was eventually complete and the patient resumed her duties as a skilled pianist.

The fifteenth error is the use of *excessive padding under plaster*. Two risks are associated with this fault: First, a slipping of the bone ends is invited. Second, even if loss of reduction does not occur, immobilization may be inadequate for prompt union. It is perhaps true that greater skill is required in the application of plaster when little or no padding is used. However, given reasonable care, the risks are less than those which follow the application of thick padding. It should be added that the skin-tight plaster should be reserved for the limb in which little or no swelling is present.

Our sixteenth way of getting into trouble consists of a broad group of *technical errors during open operations*. Technical mistakes which result in infection, gangrene or skin loss are not frequently encountered today. However, any elective proceuure involving open reduction, internal fixation or removal of a surplus part of the skeleton[8] requires the most perfect of operative technic despite our progress in bacteriostasis. The technical errors which I would emphasize are the following: (1) Too small or badly placed incisions; (2) failure to obtain good reduction before fixation, especially in the pinning of fractures of the femoral neck; (3) permitting the presence of distraction of bone ends during application of a plate; (4) too short plates and too short screws; and (5) improper metals or combinations of metals.

To conclude the list of mistakes which may be made during actual treatment of the fracture, I would list as our seventeenth a group of *errors in treatment of compound fractures*. A large literature is appearing on the primary suture of these injuries. I must express the hope that the lessons of two wars will not be forgotten, for primary closure of contami-

nated wounds is a satanic trap to the surgeon of less than mature judgment. Conservative excision, wide incision, open packing and delayed suture must be the program in the majority of cases.[9–14] Delay in operation, inadequate operation and overconfidence in bacteriostatic drugs and sera might well sum up the pitfalls in this important class of cases. The marked improvement in results during our lifetime has been due largely to the more widespread appreciation that adequate operative treatment must be carried out, followed by the planned timing of dressings and secondary operations.[15,16] The bacteriostatic and bactericidal drugs and the wider use of transfusions have been important adjuncts. The introduction of new metals has made internal fixation more applicable to compound as well as to simple fractures. The pneumatic tourniquet has aided in the economy of blood with less danger of secondary damage.

ERRORS DURING THE HEALING PERIOD OF THE FRACTURE

Under the eight preceding headings we have considered the points of difficulty during the actual reduction and fixation of the fracture. At this juncture there is no more common error than number eighteen which is *failure to maintain close observation during healing.* Coupled with this heading is the constant necessity for promoting the patient's morale through attention to his diet, his rest and his emotional acceptance of the inevitable prognosis in terms of end result and time required. It is during healing that the patient can do most to help himself, and the confidence in his advisors which he has acquired since his injury must be maintained until healing is complete and function is restored.

Failure to check maintenance of reduction by x-ray films is the nineteenth pitfall. The immediate postreduction film may show adequate replacement of the bone fragments, yet later examination reveal that the fragments have slipped out of place. This is particularly liable to occur if excessive padding is applied beneath the plaster, if joints above and below the fracture are not fixed or if marked muscular atrophy has taken place. Clinical attention to the patient's own symptoms and sensations will assist in the timing of check x-ray films, enabling slipping to be diagnosed earlier than by any simple strict routine. Both clinical and radiologic guides must be used in the timing of changes of plaster, institution of exercise and reassessment of prognosis. Everyone interested in the treatment of fractures realizes that fractures of both bones of the leg, especially of the torsion type, are extremely difficult to hold in position. As McKim has pointed out, slipping of such fractures is evidently due to atrophy of the thigh and calf muscles, permitting displacement of the proximal fragment of the tibia owing to movement of the femur in relation to the cast. He has made a specific recommendation regarding the care of such patients in order to avoid such displacement.[17] In emphasizing adequate x-ray control during healing, one must insert a warning against too frequent x-ray exposure. Wilkins and Regen have presented evidence that bone growth and bone phosphatase activity can be impaired by overdoses of roentgen radiation.[18]

The twentieth error is *maintenance of the limb in a non-physiologic position.* It is occasionally necessary to immobilize a limb in an abnormal position at the time of the initial reduction. However, this position should not be maintained any longer than is absolutely necessary. Whenever possible the maximum functional position should be maintained throughout fixation. A good guiding principle is to place the limb so that as many as possible of its normal functions can be carried out despite the presence of a fixation device. McKim defines the functions of the hand as follows: (1) to feed oneself, (2) to earn a living and (3) for purposes of offense and defense. His teaching is that a good plaster can immobilize the wrist while preserving all three of these functions. He adds as a general dictum based on his own wide experience, and I quote: "Joints do not tend to become stiff when fixed in a functional position."[19]

Application of unpadded plaster while edema is present is our twenty-first mistake. This applies especially to the unpadded walking cast.[3,20–24] When such a cast cannot be applied before swelling has occurred, it is important to wait until all edema has been dispersed. Otherwise stiffness and swelling will result and the value of the method will be lost. Furthermore, the limb will tend to chafe inside the plaster after periods of recumbency, with damage to the skin and loss of absolute fixation.

The twenty-second error is *failure to instruct in the use of appliances.* In the use of crutches

severe falls are frequent because the surgeon has failed to instruct the patient to "walk up to your crutches, never get ahead of them." Most cases of crutch paralysis occur because the patient has never been told not to bear weight in the axillae. Safe walking in the Thomas walking caliper requires specific instruction, especially in going up and down stairs. The patient must appreciate the necessity for negotiating stairways in sideways fashion, leading off with the caliper when going down but with the sound leg when going up. The patient in a walking cast must be told to avoid a gait which involves extreme external rotation of the foot. Such a gait is instinctive whenever the ankle joint is fixed; but if it is allowed to become habitual, a traumatic flat foot will result.

Our twenty-third and easiest of all ways of getting into trouble in the care of fractures is *too early mobilization or unprotected weight-bearing*. Optimism on the part of doctors regarding the length of time required for consolidation of fractures of the femur and tibia as well as of the bones of the foot is, I believe, one of the commonest and most serious errors made in the treatment of fractures. The same applies to fractures of both bones of the forearm. As a general rule it would be wise for us all to read months rather than weeks into the recommendations made in most textbooks. During a long experience in the examination of victims of injury for medicolegal purposes I have come to the conclusion that too early mobilization and too early unprotected weight-bearing has been the most important cause of prolongation of temporary total disability and of increase in the permanent partial disability. It would be easy to accumulate large numbers of cases to support the above thesis. I believe, however, that the frequency of bending of fractures of the tibia, refracture of the femur as well as the comparative frequency of true non-union in fractures of the ulna should convince anyone of the correctness of this statement.

Our twenty-fourth method of delaying our good result is *delay in rehabilitation*. Perhaps this is better described as neglect to maintain the patient in the best possible general and local condition. Attention to diet and factors of morale must be combined with instruction in local and general active exercise. In this connection occupational therapy offers considerable aid.

Our final warning, number twenty-five, goes hand in hand with the previous heading and consists of *too early and ill conceived physiotherapy*. The older textbooks advised early passive movement and this fallacy has taken years for exposure. The dangers of stiffness and vasomotor disturbance will be largely avoided if passive movement is forbidden. However, overly vigorous active motion which causes pain may be equally damaging. Finally, the surgeon must check that the active exercises being taught to the patient are not simply fatiguing accessory muscles without action on the part of the involved muscle group which the therapy should be aiming to restore. Patients endeavoring to restore flexion to fingers are frequently found to be working only the intrinsic muscles of the hand, flexing and extending the metacarpophalangeal joints, often without any perceptible contraction of the flexors in the forearm being achieved. Fractures about the elbow must be protected from physiotherapy for the longest possible time. The consequences of even the mildest passive stretching in this area are particularly severe. In my practice I do not wish to be quoted as opposed to physiotherapy, but when I am asked how soon after injury an elbow fracture should be turned over to that department, I generally reply: "Any time after the eighth month."

CONCLUSION

We have concluded our account of twenty-five easy ways of getting into trouble between the beginning and end of our contact with the fracture patient. Nothing less than a continuing interest in improving our results must be our constant care if we as general or community surgeons are to retain our right to treat this class of trauma. In the beginning I quoted from Dr. Darrach's synthesis of the whole problem of fracture care into a "wise plan of action." No one was better qualified than he to emphasize the overriding importance of that quality of wisdom.

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EXPERIMENTS ON THE HOLDING POWERS OF VARIOUS TYPES OF METALLIC INTERNAL FIXATION FOR TRANSCERVICAL FRACTURES OF THE FEMUR*

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WHILE metallic internal fixation for transcervical fracture of the femur has been in common use for more than fifteen years, it has only been during the last few years that a critical analysis of the results has pointed out some of the factors that must be observed to obtain the best results for each individual patient. It is generally agreed that early control of the patient by the surgeon, anatomic reduction, secure fixation and regular and prolonged postoperative supervision are required. Certain of the detailed steps of this program are still under discussion.

No less than thirty different types of metallic fixation, more than fifty accessory gadgets for measuring, sighting, directing and placing the fixation material and hundreds of articles describing the use of these numerous and ingenious devices are found in the surgical literature. No attempt will be made to catalogue this knowledge, but a safe conclusion to be drawn at this time is that the results can still be improved.

Early and exact reduction undoubtedly conserves the blood supply which is so important in this fracture. Metallic fixation is to be regarded only as an efficient and temporary internal splint to carry the patient over the period until the fracture heals. Healing will be shorter the more efficient and the less destructive the type of internal fixation used and the less traumatic the technic of placing the fixation device. Absorption of the neck is due to excess motion during the healing period and since all non-viable material produces pressure necrosis and loosens if sufficient strain is thrown upon it it is desirable to utilize the most efficient immobilizing devices and to obtain the most stable reductions.

It is difficult to segregate and analyze data in the human patient. However, the proof of several points appears now to be beyond question. Compere and Wallace have furnished experimental proof that early and accurate reduction leads to prompt union with a viable head. The same conclusions are inferred from the statistics of individual surgeons who have reported a high percentage of favorable results. The elimination of shearing stress and its corollary, a stable reduction, has been pointed out by those who have given particular attention to the inclination of the fracture line (Pauwels, Eyre-Brook and Priddie and Linton) and by those who have advocated various types of osteotomies. Wellmerling has pointed out the advantage of utilizing the thick cortical bone a short distance down the lateral femoral shaft to hold the internal fixation pin which is driven upward through the neck and head at as oblique an angle as possible. This assumes the use of longer fixation materials and their passage through the inferior third of the proximal femoral neck, a region where osseous trabeculae are best developed. McElveny pointed out that temporarily increased longitudinal traction accompanied by medial displacement of the lower fragment will often secure rotation of the head with a more horizontal and stable fracture line.

It has been the experience of all surgeons that it is impossible to determine the time of secure osseous union in transcervial femoral

* Experimental work for this paper was carried out at The Guthrie Clinic and The Robert Packer Hospital, Sayre, Pa.

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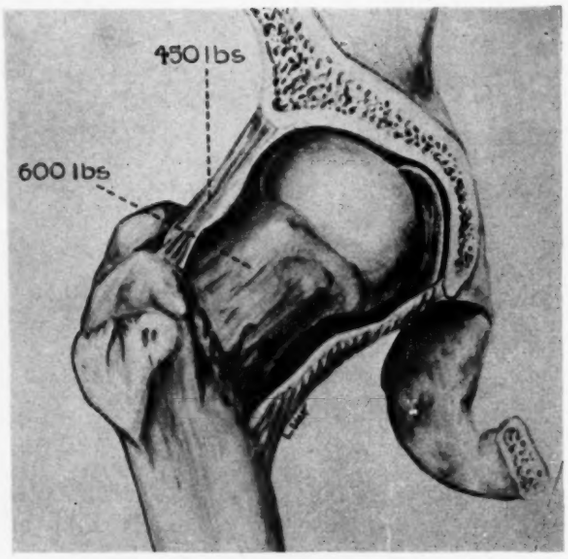


FIG. 1. Diagram summarizing average forces required to disrupt certain structures about the hip in fresh unpreserved cadaver specimens. The figures at the capsule in the femoral neck were the averages required to rupture these structures by a distracting force. Average crushing force to fracture the neck is 1,500 to 2,000 pounds; averages of four tests.

fractures until it has become far advanced. Internal fixation as a result must be left in place for many months after resumption of weight-bearing. The introduction of autogenous grafts appears to accelerate union, but the majority of surgeons consider that they are unnecessary in fresh cases except in unfavorable instances and in those showing complications in which extra stimulation is required. There is no agreement on schedules for postoperative care. Some surgeons favor extremely early and vigorous use of the extremity while others recommend rest.

The minimum of trauma in transporting the patient and in securing reduction compromises the blood supply the least and adds to the comfort of the patient. Skeletal weight traction (5 to 8 pounds) with internal rotation and local anesthetization of the hip area is unquestionably the least traumatic method of obtaining reduction. Technics are also available (Harmon) for reduction and insertion of the internal fixation without transferring the patient from his bed. This undoubtedly minimizes trauma.

This paper is an experimental investigation of the holding power of various types of internal fixation. The conditions for the tests were uniform and were carried out on preserved upper femora of dissecting room cadavers. (Figs. 1 and 2.) The values obtained are, of course, not identical with those of living man because of the difference between preserved dead bone and viable bone. The comparisons obtained are likely to hold for the same region in living bone. It is recognized that the type and technic of inserting internal fixation is not the sole factor involved in treatment of transcervical fractures in the human, but a study of the mechanics of internal fixation is likely to improve the practical application of the same devices in patients. The data summarized in this report were secured in experimentally produced fractures across the femoral neck of 242 selected specimens* from approximately 400 trials. The estimations were of two types (Figs. 3 and 4): the holding power against a distracting force directed coaxially with the neck and a determination of the resistance of the specimens to a superior-inferior crushing force. As will be described later the experimental specimens gave way in different zones, varying with the type of fixation employed and the hardness of the material.

EXPERIMENTAL METHODS AND MATERIALS

Five or 6 inches of the upper femur were removed from cadavers by cutting away the joint capsule and transecting the shaft with a saw. The specimens were kept moist by towels soaked with preservative solution during transportation and until the tests were carried out. A superior-inferior cut with a saw was made across the mid-portion of the femoral neck at a 30 degree angle with a long axis. (Figs. 5, 6 and 7.) The tubular subtrochanteric shaft was mounted in a vice in the laboratory and the fixation material introduced from the trochanteric side with an assistant holding the femoral head in place. Observations were made during the insertion of the fixation material, and approximately every tenth specimen was subjected to roentgen examination as a control on the depth and direction of insertion of the metallic fixation. The experimentally fixed fractures were then subjected to distrac-

* The authors are indebted to the Professors of Anatomy of the following medical schools who kindly placed the dissection room specimens at our disposal: The University of Pittsburgh, The University of Buffalo, The University of Rochester, Syracuse University, The University of Pennsylvania, Temple University and The Jefferson Medical College of Philadelphia.

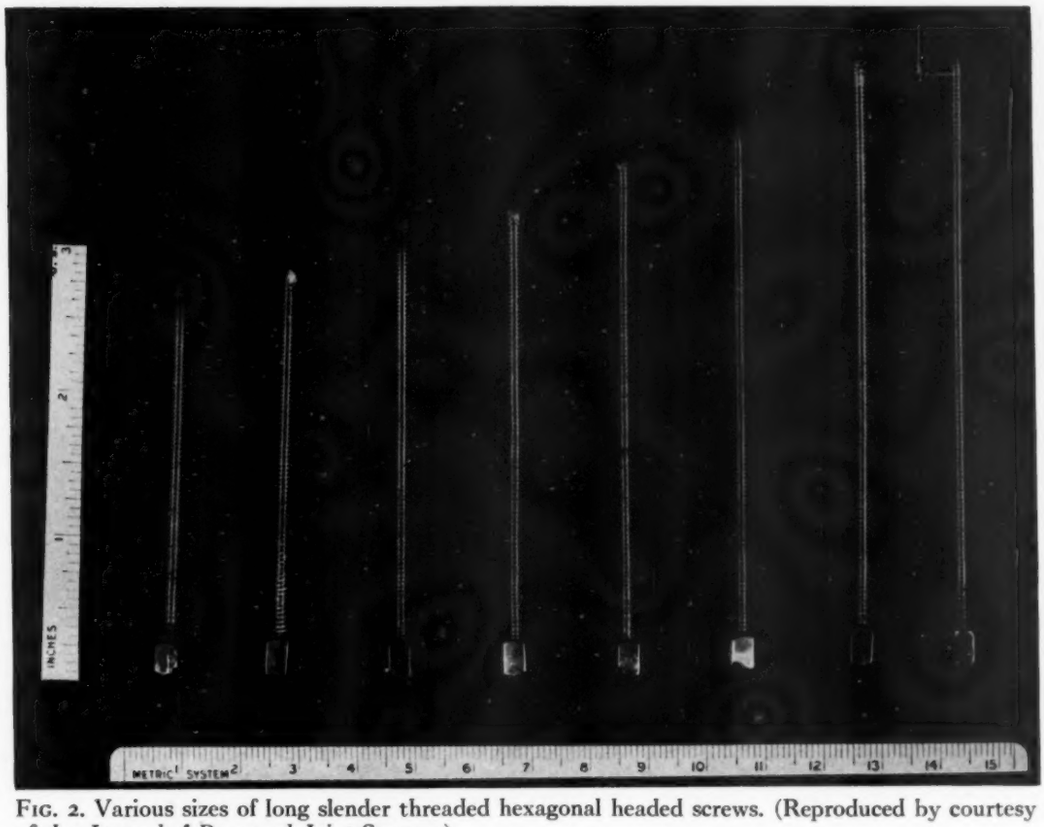


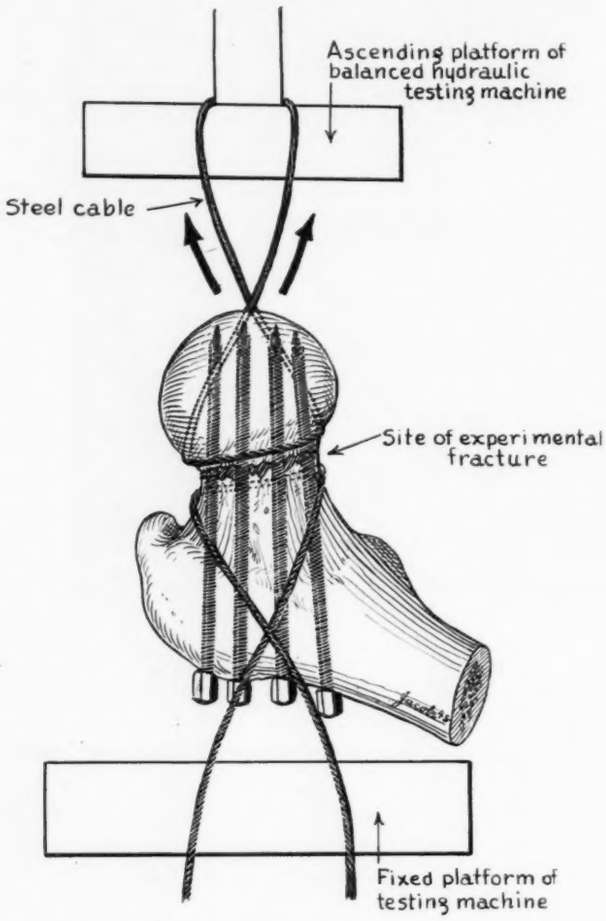
FIG. 2. Various sizes of long slender threaded hexagonal headed screws. (Reproduced by courtesy of the *Journal of Bone and Joint Surgery*.)

tion and crushing, between the tables of a beam-balanced hydraulic press of a type commonly used in engineering laboratories in determining tensile strengths.* Observations on the specimens were made during and after the tests. The end point of the test was the earliest grossly detectable sudden yield or separation at the fracture site or elsewhere in the specimen. This might be detected either by direct inspection or from a sudden deflection of the balanced beam which would indicate giving way of the specimen. The portion of the specimen which broke and the mode of separation varied with the type of fixation. While it was impossible to secure enough specimens to make the results of statistical order, sufficient duplications of each type of test were performed in order to secure fair median values. The numerical values of these tests are recorded in pounds in Table 1. Photographic and roentgen records of the results in representative selected instances were made. (Figs. 5, 6 and 7.)

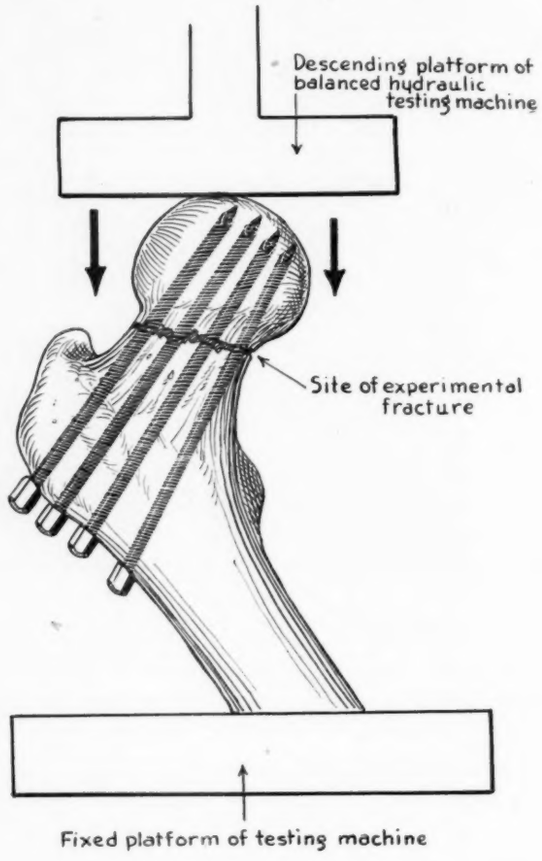
Twelve types of fixation materials, Tables 1 and 11, were selected as being representative of all types of internal fixation for transcervical fractures of the femur. The Smith-Petersen tri-bladed nail and the Cubbins-Callahan-Scuderi flange were selected as representatives of sharp, rigid fixation materials. The blade of the Neufeld nail has similar properties. The Thompson Z-nail was representative of a semi-rigid device. The group of large helicoid devices was represented by the Moreira lag screw, the Lorenzo screw and the Lippmann corkscrew bolt. Smooth rigid pins were illustrated by stainless steel Steinmann type pins ($\frac{5}{32}$ inch in diameter). Larger screws, such as the Geckler screw and the Venable type large Vitallium wood screws, were used. Slender threaded pins of the three types described by Moore, Compere and Harmon were used. The proximal half of the Moore pin is unthreaded while threads extend the entire length of the slender shaft of the two latter type slender pins. The Compere threaded wires are 0.080 inch in diameter with fifty-six turns to the inch. Two sizes of the long slender hexagon headed screws (Harmon), 0.125 inch and 0.156 inch in diameter threaded with a sharp die, 32 turns to the inch and with respec-

* These estimations were carried out in the testing laboratory of The Lehigh Valley Railroad, Sayre, Pa.

tive root diameters of 0.094 inch and 0.120 inch, were tested. Thin stainless steel washers ½ inch in diameter and acrylic resin plates 3/16 inch thick (Fig. 8) were used in some experiments to back up the thin lateral upper region was distributed over a larger area by inert substances, such as stainless steel washers or the acrylic resin plates as shown in Figure 8. Reference to Table 1 shows these increased values.


Ascending platform of balanced hydraulic testing machine
Steel cable
Site of experimental fracture
Fixed platform of testing machine

3


Descending platform of balanced hydraulic testing machine
Site of experimental fracture
Fixed platform of testing machine

4

FIG. 3. Diagram showing the mounting of specimens for determination of the force required to distract experimentally produced transcervical fractures. Note that separation can occur by either pulling the head from the fixation device or by the fixation device holding in the head and pulling through the lateral trochanteric shell.
FIG. 4. Diagram of the positioning of specimens for determination of superior-inferior crushing force.

femoral cortex above and immediately below the vastus externus line.

A classifying list of the representative types of fixation materials whose holding power was tested is given in Table II. It should be recalled that Vitallium is a cast alloy and is softer and more brittle than surgical stainless steel. After a few tests it became evident that when the screw type fixation materials were used, better impaction was secured in experimental fractures and consequently higher holding power values when the counter pressure against the lateral femoral cortex in the trochanteric

OBSERVATIONS AND RESULTS OF TESTS

The observations made on the experimental specimens during the introduction of fixation materials and later as they were tested are of importance equal to the numerical force values taken at the breakdown of the specimens. When a smooth surfaced type of fixation material, such as the tri-bladed nail, the Cubbins-Callahan-Scuderi flange, the Z-nail or Steinmann pins, was introduced, a certain amount of manual pressure was required to keep the central fragment from being driven

TABLE 1

SUMMARY OF DISTRACTION AND CRUSHING TESTS OF FIXATION MATERIALS IN EXPERIMENTAL TRANSCERVICAL FRACTURES

Type of Fixation Material	Distraction Tests			Crushing Tests			Remarks on Tests
	No.	Median (lb.)	Maximum (lb.)	No.	Median (lb.)	Maximum (lb.)	
Smith-Petersen tri-bladed nail	6	170	300	11	800	1110	Nail cuts cancellous bone; sometimes bends on crushing
Cubbins-Callahan-Scuderi flange	4	170	150	13	490	800	Nail cuts cancellous bone
Thompson Z-nail	2	50	50	4	400	470	Nail bends on crushing
3 Steinmann pins (5/32 inch diameter)	4	30	30	8	750	1080	Pins usually cut upper shaft cortex on crushing
4 Moore pins (parallel)	4	70	130	6	540	700	Pins bent upon crushing
2 Geckler screws	6 6 (washers)	540 830	1100	8	530	1960	Pins bend often on crushing but cut bone on soft specimens
Moreira lag screw	5	200	345	4	600	720	Pulls out core of bone; shaft of device bends on crush test
Lorenzo screw	5	320	340	5	700	770	Cortex on shaft side pulls out unless placed low; screw cuts head on crush
Lippmann corkscrew bolt	3 3 (washers)	320 550	1010	6	620	700	Holding power increased by adding washers to buttress lateral cortex
2 large Vitallium wood screws	4	260	270	6	500	850	Screw brittle; shaft breaks on crushing
3 capped stainless steel screws (0.125 inch diameter)	16 4 (washers or plates)	330 580	990	8	640	1450	Washers or plastic plates improve resistance of lateral femoral cortex and raise resistance to distraction; on crush shaft of screws cuts cancellous bone of neck and head
4 capped stainless steel screws (0.125 inch diameter)	12 8 (washers or plates)	590 840	1190	10	600	1650	
5 capped stainless steel screws (0.125 inch diameter)	12 2 (plates)	600 990	1550	10	800	1200	
3 larger stainless steel screws (0.156 inch diameter)	8	250	540	6	460	720	
5 Compere threaded wires (0.080 inch diameter)	8	280	380	15	360	710	
Unfractured controls	14	710	1240	19	2550	4050	

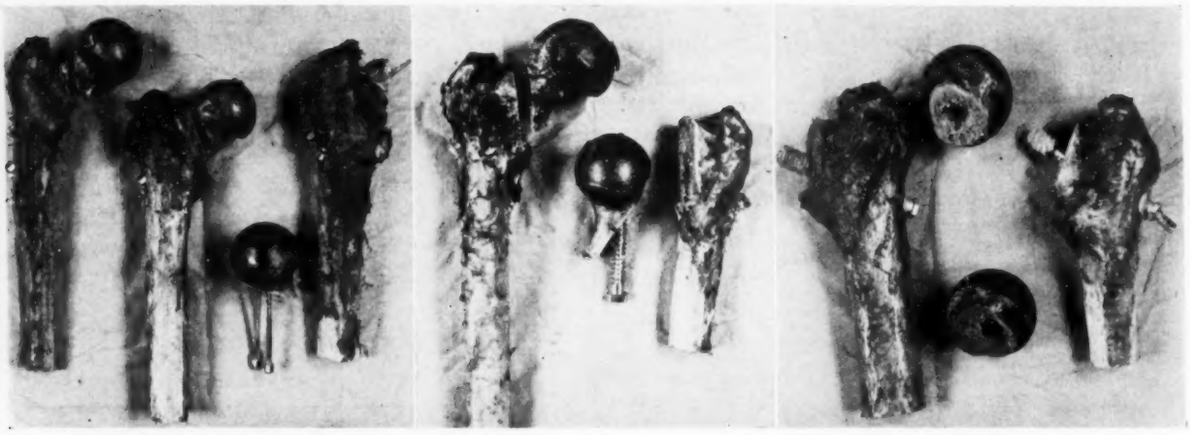


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FIG. 5. Specimens from three experiments of the determination of distracting force. In the two specimens on the left the femoral head was pulled from the screws and all the screws held in the proximal fragment, because most of the screws were inserted low enough on the lateral femoral cortex to take advantage of thick cortical bone. In the specimen on the right two of the screws held in the head and the screw heads pulled through the lateral cortex and trochanter.

FIG. 6. Anteroposterior and lateral views of two specimens in the distraction experiment utilizing the Lorenzo screw. The screw was removed from the specimen on the left prior to photography, but in both instances the screw held in the central fragment and pulled through the lateral femoral cortex.

FIG. 7. Specimens from two distraction experiments utilizing the Moreira lag screw. Note that the hold on the femoral head was secured by cancellous bone between the screw threads. When distraction occurred, the device retained a core of cancellous bone and the femoral head pulled free. The device held in the distal fragment because of the distribution of stress over an area of the lateral cortex by a curved plate.

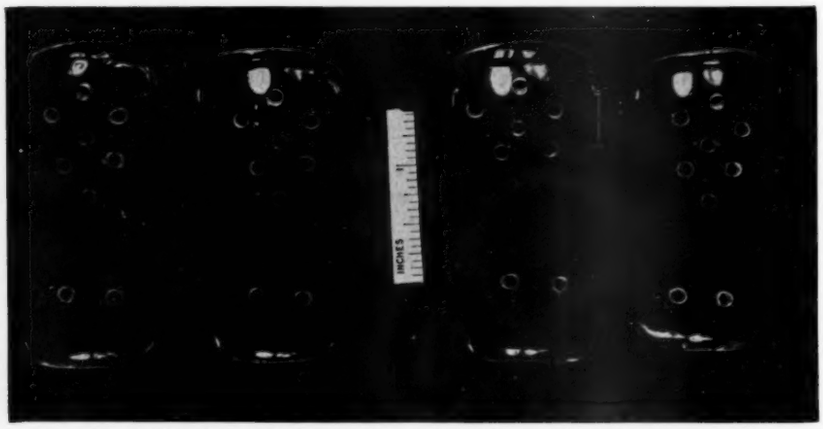

FIG. 8. Small 3/16 inch thick acrylic resin plates used to buttress the lateral cortex of the upper femur.

away from the proximal one. This signifies trauma to the articular cartilage in patients. Obviously the introduction of such types of fixation takes place more readily in living bone than in the dead bone of the specimens. Any impaction at the fracture site was the sole result of mechanical impaction imparted in a central direction to the trochanteric fragment, signifying additional trauma. No such tendencies of the central fragment to escape from the proximal fragment were noted when the screw types of fixation engaged the central fragment. In general, the smaller the diameter of the screw the less motion was imparted to the central fragment. Deep introduction of all types of screws into the central fragment pulled this fragment toward the distal fragment irrespective of the presence or absence of threads on the portion of the device passing through the trochanteric area. In the instance of the Moore pins, which are smooth on the distal half, no such impaction with introduction was observed. When an initial gap of ¼ to ½ inch was present at the fracture site, the gap was eliminated and the fracture surfaces became impacted as the screws were tightened.

When stainless steel washers or acrylic plates were used to buttress the lateral femoral cortex, powerful impaction was secured. This action was reflected in the regular 50 to 70 per cent increase in the values required for distraction in the tests.

It should be pointed out that the ability of a screw to engage the central fragment is in proportion to the total surface area introduced into the central fragment. Multiple slender screws with many turns to the inch afford more holding surface in proportion to bulk than do the lag screws. This fact was further borne out in the frequent observation in the distraction tests that the long slender hexagon headed screws would hold in the central fragment and the heads of the screws would pull through the upper lateral femoral cortex and the trochanteric region (Fig. 5) when distracted while the femoral head would be pulled free from the lag screws with a core of cancellous bone remaining between the threads. (Fig. 7.) This latter observation differed in some tests depending upon the amount of counter pressure distributed over the lateral femoral cortex. As a result the Moreira lag screw, which is equipped with a Vitallium plate against which the outer screw is tightened, (Fig. 7) illustrates the first situation while the illustration of Figure 6 (Lorenzo screw) was an instance when the butt of the screw pulled through the lateral femoral cortex as forcible distraction occurred. The Lippmann Vitallium cork screw bolt invariably pulled through the lateral femur until the washer was used to buttress this region. (Table 1.)

The numerical values of forces required for distraction (Table 1) were lowest when the smooth-surfaced devices were under consideration. The five devices listed first in Table 1 were the least satisfactory in the distraction tests. The screw types of fixation regularly demonstrated two to three times the holding power of the five first mentioned devices, and the holding power increased with the number of screws used and became 45 to 75 per cent greater when the lateral cortex was buttressed with stainless steel washers or acrylic plate. The highest values were secured with the Geckler screws and four and five hexagonal headed slender stainless steel screws. It should be pointed out that the maximum values obtained with these devices exceeded the maximum force required to pull the femoral head from an unfractured specimen.

All the devices tested regardless of their architecture showed up well in the crushing test to a superior-inferior force. Comparisons should not be closely drawn between the different types of devices since the nails, flanges, Steinmann pins and slender stainless steel screws cut the cancellous bone of the head and neck before the fixation device bent. When the flat surface of the Thompson Z-nail was oriented toward the crushing force, this type of fixation was observed to bend before cutting the cancellous bone. This same observation was also made with Moore pins, occasionally with Geckler screws and on the shaft of the Moreira lag screw. In the instance of the large Venable type wood screws the screws themselves often fractured transversely. The devices which showed up best in the crushing tests were the Smith-Petersen tri-bladed nail, three $\frac{5}{32}$ inch Steinmann pins, all the lag screws and all the slender screws. The resistance to crush in none of the experimental specimens even approximated the force required to fracture an intact preparation without fixation (note the values obtained in Table 1 with unfractured controls).

TABLE II

CLASSIFICATION OF MATERIALS USED FOR FIXATION OF FEMORAL NECK FRACTURES BASED ON RESISTANCE TO TESTS*

- Little Resistance to Distraction; Good Holding on Crush
  - Smooth surfaced Vitallium appliances
    - Smith-Petersen nail
  - Smooth surfaced stainless steel appliances
    - Cubbins-Callahan-Scuderi flange
    - Stainless steel Smith-Petersen nail
    - Neufeld nail
    - Thompson Z-nail
- Good Resistance to Distraction; Good Holding on Crush
  - Vitallium screw appliances
    - Godoy-Moreira lag screw (stud-bolt)
    - Lippmann corkscrew bolt
    - Venable type large Vitallium wood screws
  - Large stainless steel screws
    - Lorenzo lag screw
  - Smooth pins offering little resistance to distraction
    - Multiple Steinmann pins
    - Moore pins
  - Rigid on fixation by threaded pins and slender screws
    - Compere threaded wires (0.080 inch in diameter)
    - Geckler screws
    - Harmon slender threaded hexagon headed stainless steel screws

* Washers or other buttress material improve strength of upper lateral femoral cortex.

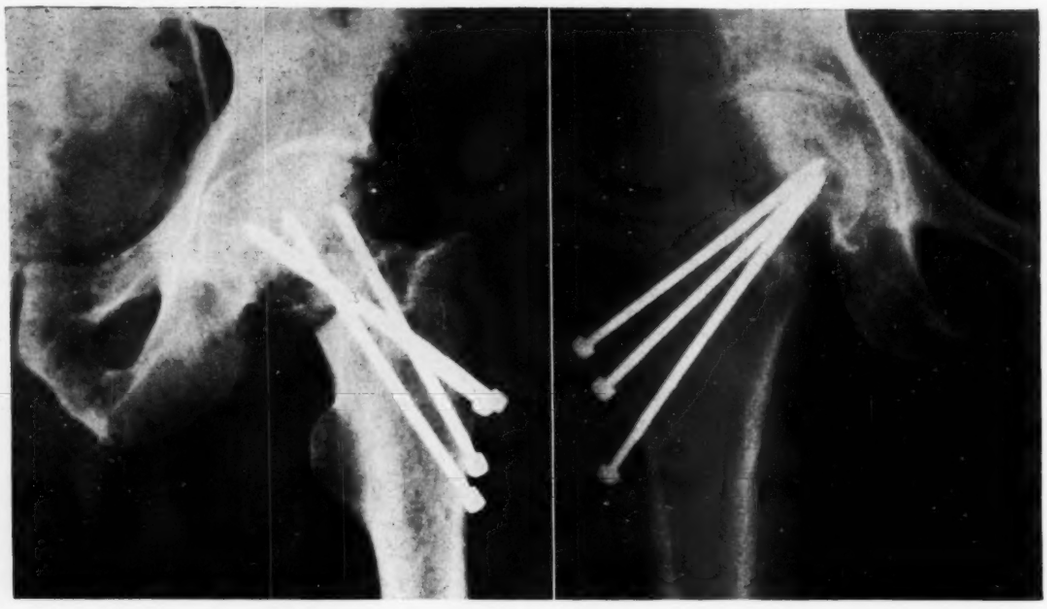

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FIG. 9. Anteroposterior and lateral roentgenograms taken immediately after fixation secured by four long slender hexagonal-headed screws. Note that the fracture line is difficult to see as the result of impaction by the screws.

FIG. 10. Anteroposterior roentgenograms of a case of a near horizontal fracture line in which impaction and even better position was secured by preliminary overtraction, slight medial displacement of the distal fragment and impaction of the distal fragment into the central fragment by screws. Weight-bearing was begun by this patient at eight weeks and crutches were discarded at twelve weeks.

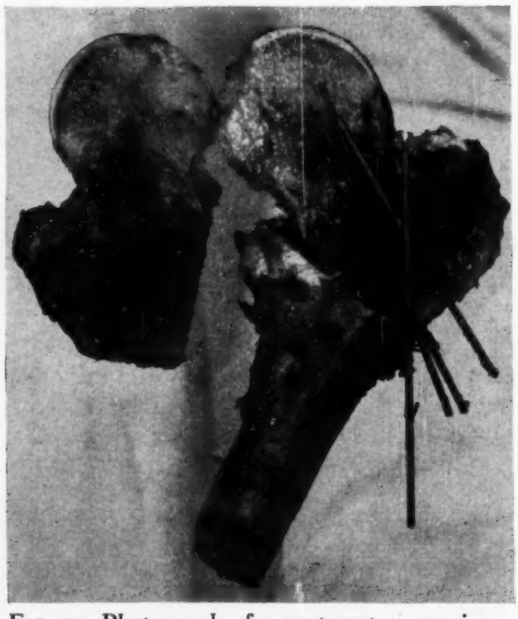

FIG. 11. Photograph of a postmortem specimen nine months after screw fixation of a fracture at the base of the neck in a patient with roentgen necrosis of the femoral head. Prior to sectioning the specimen the screws had been withdrawn, their heads removed and then partially reinserted. The specimen demonstrates substitution of most of the lateral half of the central fragment. There was clinical healing of this fracture.

APPLICATIONS OF EXPERIMENTAL OBSERVATIONS TO TREATMENT OF TRANSCERVICAL FRACTURES IN MAN

The experiments described in this paper were carried out after the long slender threaded hexagon headed screws had been used for some years in the treatment of transcervical fractures in man. In a previous report (1945) of results in thirty-five cases in which this type of fixation was used satisfactory union with a viable head was secured in thirty-one cases, or 88.6 per cent. There was no necrosis of the femoral head, a fact which was attributed to the institution of traction-reduction on the same day of the fracture in thirty-three of thirty-five cases. Trochanteric osteotomy was judged necessary in three cases of delayed union with vertical or near-vertical fracture lines. A frank case of non-union occurred in one patient who was in a precarious state of health, blind and bedridden. The cause of the non-union was an unsatisfactory reduction which persisted after different attempts to better the position. Since publication of the former report, similar statistics are available on eighteen additional cases. There have been no non-

unions and no necrosis of the femoral head except in a single case in which three pins fractured under unusual circumstances in a thirty-three year old patient who subjected this region of the anatomy to unreasonable and undue stress too soon after operation and against the advice of the surgeon. Figures 9 and 10 are roentgenograms of representative cases in which this type of fixation was used. Figure 11 is a photograph of a specimen in which these types of screws were used in a patient suffering from roentgen necrosis and transcervical fracture. Partial substitution was observed during the lifetime of this patient. The full technic which was used by the authors was described in the previous publication (1945) and will not be repeated here. It should be pointed out that traction-reduction, introduction of fixation with minimal moving of the patient prior to fixation and two to three months' partial bed rest are considered to be just as important, or more important, than the type of fixation used. No patient was allowed to bear weight on the fractured extremity even with the aid of crutches until six to ten weeks after reduction and fixation of the fracture. This period is determined from roentgenograms made at six weeks.

SUMMARY AND CONCLUSIONS

The holding power to distracting and crushing forces was estimated for twelve types of internal fixation materials that are commonly used in the treatment of transcervical fractures of the femur in man. These twelve types of materials were selected for testing in experimentally produced transcervical fractures in cadaver specimens because they were representative of the entire group of metallic internal fixation devices used in these fractures. The numerical values obtained in 242 tests are given and the observations made during this work are described. Included in the devices are multibladed nails, steel flanges, Steinmann pins, special slender pins and screws and various types of lag screws.

Fractures immobilized by the hexagon headed slender stainless steel screws yielded the highest values on resistance to both distraction and crushing. The holding power of these screws against a distracting force was increased 45 to 75 per cent by buttressing the trochanteric and upper lateral femoral cortex with stainless steel washers and plastic plates. These values even exceeded the force required to pull the femoral head from an unfractured specimen.

All the devices tested showed up well on crushing. Especially high values were observed in the tests for the Smith-Petersen tri-bladed nail, several Steinmann pins ($\frac{5}{32}$ inch in diameter), the various lag screws and multiple long slender hexagon headed screws.

The results are given in fifty-three cases of transcervical fracture in man treated by early reduction and a precise regimen in which the long slender hexagon headed screws were used for fixation. Direct union without other procedures was observed in forty-five of fifty-three cases (84.9 per cent). Trochanteric osteotomy within six months after fracture was performed on the surgeon's judgment in six cases in which union was observed not to occur promptly. The two instances of non-union were observed to follow reduction failure in one instance and to fracture of the screws in an unreasonable and hyperactive patient. There were no instances of necrosis of the femoral head. The minimum follow-up period was one year and several patients were followed for six years.

The long slender hexagon headed screws serve as their own guide or pilot pins. They are introduced atraumatically with a drill and can be withdrawn and reinserted easily and without damage to the bone. The depth of insertion can also be adjusted after control roentgenograms.

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END RESULTS IN SEVENTY-SEVEN CONSECUTIVE FRESH FRACTURES OF THE NECK OF THE FEMUR*

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STIMULATED by the excellent and frank report on the pitfalls in management of fractures of the neck of the femur which contribute to non-union by Siris and Mulholland[1] at last year's meeting of this association, and echoes of Speed's oration[2] on the "unsolved fracture" ringing in our ears much clearer than at the time of its delivery in 1935, we decided to examine our own end results more thoroughly. One of us had the temerity to report the "solution of the unsolved fracture"[3] based on two factors, namely, an accurate reduction with internal fixation and a special protractor with which to do it. We now retract the protractor.

The following is a review of seventy-seven consecutive fresh fractures of the neck of the femur treated at the Jackson clinic between the years 1936 to 1946, inclusive.

In this series thirteen, or 17 per cent, were under sixty years of age; eighteen, or 23 per cent, between sixty and seventy years; forty-five, or 59 per cent, between seventy and ninety years and one over ninety years old. Nine, or 12 per cent, were males while sixty-eight, or 88 per cent, were females. Twenty-two, or approximately 30 per cent of the patients had impacted fractures and all made uneventful recoveries except one who was submitted to internal fixation and subsequently developed absorption at the fracture site and aseptic necrosis of the head. On checking the films taken at operation it was found that the impaction had been broken up by the insertion of the nail and had not been sufficiently corrected. There were nine patients in the impacted group who showed moderate degenerative arthritic changes, six with coxa vera, but all had good functional results with full weight-bearing. There were three deaths in this group from two to nine years following injury.

The treatment of those with impactions was conservative, consisting of bed rest, light Russell's traction, 4 to 5 pounds, or balanced traction suspension with a Thomas splint and Pierson attachment for one month to six weeks, then a wheel chair and partial weight-bearing with crutches and full weight-bearing at three to six months No disrupted impactions or other complications developed during hospitalization, largely due to excellent nursing care. Patients received frequent change of position, checking of suspension apparatus and, most important of all, active muscle exercises from the start. Weekly or biweekly X-ray checks, anteroposterior and lateral, were made, or whenever the occasion demanded.

Of the fifty-five displaced fractures of the neck, subcapital, transcervical and basal, fifty-two were treated by internal fixation with the Smith-Petersen three flanged nail under spinal anesthesia. The three patients not operated upon died twenty-four hours, forty-eight hours and one week after injury from uremia, multiple injuries following an automobile accident, and parkinsonism with pneumonia, respectively.

One case is considered a true operative mortality, a sixty-seven year old female with pernicious anemia died seven days postoperatively of uremia. All other deaths during the period of this survey occurred from three months to nine years postoperatively. The overall mortality in the displaced group numbered twenty-two or 40 per cent.

The technic of preparation, reduction and fixation by "blind nailing" has been described elsewhere by Jackson.[3] The only deviation being that during the period of 1940 to 1943 the Cubbins-Callahan-Scuderi[4] approach was used in nine cases, in one of which a portion of the anterior capsule was found to lie between the fragments preventing an accurate reduction preoperatively.

The principles generally adhered to were: (1) Anteroposterior and lateral X-ray examinations on admission; (2) immediate traction; (3) evaluation of physical condition with sup-

* From the Jackson Clinic, Madison, Wis.

portive therapy; (4) accurate reduction using modified Leadbetter technic; (5) lateral nailing with Smith-Petersen nail; (6) impaction; (7) light traction for one week; (8) early ambulation and discharge from the hospital in three weeks using crutches; (9) discard crutches at three months; (10) follow-up X-rays at three to four-month intervals for two years.

There is no doubt that these patients seemed to do better initially than some of those with impacted fractures. Their morale was high, their hospital stay was shortened and the financial burden was lightened. Initially, we were relying on the nail to do the trick, but we were enjoying a false security. In this group there were six non-unions, or 11.5 per cent, twenty-eight, or 53.8 per cent, showed aseptic necrosis and thirty-five, or 67.3 per cent, of these patients had degenerative arthritic changes of various degrees, characterized on X-ray by lipping, diminution of joint space, coarseness of trabeculations, thinning and eburnation of the articular cortices. Every case in this series of aseptic necrosis was accompanied by degenerative arthritic changes from moderate to severe degree. It is difficult to tell how much of the hypertrophic or posttraumatic arthritic changes are the direct result of trauma as the majority of patients in this advanced age group usually have modifications of these changes.

The nails were removed in eighteen cases at various intervals after one year when aseptic necrosis had occurred; in ten cases the nail was loose and partially extruded and the cannulated portion filled with necrotic débris on microscopic examination. Cultures of these specimens were negative except for a growth of streptococcus viridans on one and staphylococcus aureus in two which was reported as a contamination. In one case the nail had bent in the middle 15 degrees; union subsequently occurred with moderate coxa vera. A similar 9 cm. nail was tested and it was found to require 575 pounds to bend it grasping it 1 inch from either end with the blade pointing vertically while only 345 pounds with the blades flat, a fact that might be considered in placement of the nail at operation.

Two proximal femoral specimens were obtained at six months postoperatively: one from a patient who had just left the office walking with a cane and who was killed in an automobile accident and the other from a bedridden decompensated cardiac. Both of these specimens seemed solid when removed, and X-rays were interpreted as showing some evidence of union but microscopic examination at the fracture site revealed only fibrous union.

The following is a case report illustrating rapid disintegration of the proximal fragment following good reduction and fixation but too early and strenuous weight-bearing in an otherwise healthy active farmer.

CASE REPORT

K. V. P., 65-455 AET. 57, was injured February 27, 1942, when an end gate of a truck struck his right hip knocking him to the ground. He was unable to get up. The patient was admitted to the hospital immediately with external rotation and shortening of the right leg.

X-rays showed a displaced transcervical fracture of the right femur. The leg was placed in 4 pounds Russell's traction and six days later Smith-Petersen nailing with Callahan-Scuderi approach was performed. A portion of the anterior capsule was interposed preventing accurate reduction preoperatively.

The postoperative course was uneventful. He was up in a chair in two days, was discharged from the hospital on March 20, 1942, or sixteen days postoperatively. He used a crutch but was permitted no weight-bearing and at two months he was using a crutch with light weight-bearing permitted. At six months he was bearing full weight and doing light farm work; and at one year he was doing heavy farm work. At sixteen months he was doing heavy farm work but he complained of pain in the right hip. X-ray showed aseptic necrosis and the patient was advised to have the nail removed.

I did not see him again until August, 1946, at which time there was severe necrosis of the head with degenerative arthritic changes; a reconstruction operation was advised but was refused.

CONCLUSION

The incidence of aseptic necrosis and degenerative arthritic changes is alarmingly high in this series.

A review of the progress of these patients reveals two factors that we believe contribute to these complications: (1) Too early weight-bearing and (2) internal fixation by lateral nailing adds a certain amount of damage to the already greatly impaired circulation.

We have not performed primary osteotomy with the greater assurance of union and reasonably good function, believing that the

immediate disadvantage of greater postoperative mortality and discomfort outweighs the advantages. We believe that the Smith-Petersen nail has stood the test of time for fixation *per se* and perhaps with the addition of a cancellous bone graft or some other means of promoting osteogenesis as well as a more careful follow-up and delay in full weight-bearing for a year or so, a more satisfactory compromise can be made to the satisfaction and comfort of the patient in this most difficult of all fractures.

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INTRACAPSULAR FRACTURES OF THE NECK OF THE FEMUR*

FOLLOW-UP REPORT OF 130 PATIENTS TREATED BY INTERNAL FIXATION WITH THE SMITH-PETERSEN NAIL

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THIS report presents some observations resulting from the critical appraisal of 130 consecutive intracapsular hip fractures treated at the Fracture Service of the Presbyterian Hospital in New York between 1932 and 1944. A Smith-Petersen nail was used for fixation in each case. All fractures of more than two weeks' duration and all trochanteric and base of neck lesions were excluded from the study so that the remarks to follow pertain solely to true, early intracapsular fractures. These will be segregated into three categories according to the classification described by Pauwels.[1] (Fig. 1.)

During the period covered by the study 255 hip fractures of all types were treated. True intracapsular lesions, therefore, compromised about 50 per cent of the total. Table 1 depicts the relative incidence and average age of the various categories described by Pauwels. These patients were unselected. Fifty-six, or 43 per cent suffered from important systemic conditions requiring correction prior to or control coincident with active treatment of the frac-

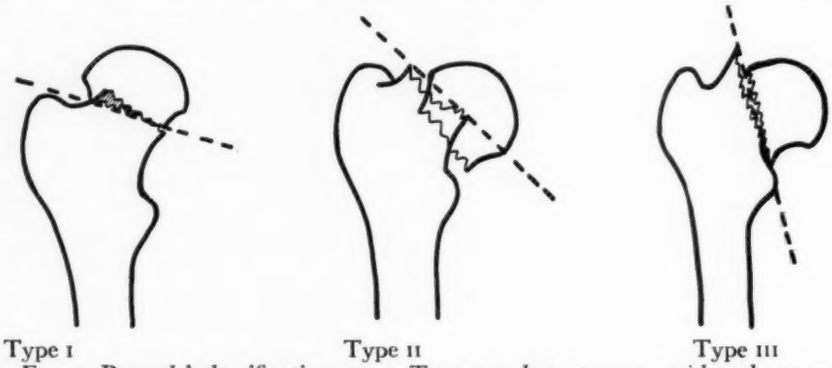

FIG. 1. Pauwels' classification, 1935. Type I, valgus; type II, mid-neck; type III, oblique subcapital.

TABLE 1
CLASSIFICATION OF INTRACAPSULAR FRACTURES

	130 Intracapsular, Per Cent	255 Total Hip Fractures, Per Cent	Average Age
26 Valgus	20	10	59
57 Mid-neck	44	22	66
47 Subcapital	36	18	66

TABLE II
MEDICAL HISTORY—130 CASES

Over 79 years of age	15
Hemiplegia	6
Other fractures	5
Cardiac failure	5
Senile dementia (severe)	4
Other psychoses	2
Pyelitis	2
Rheumatoid arthritis	3
Malignancy	3
Parkinsonism	2
Diabetes	3
Bronchopneumonia	3
Cataracts	1
Burns	1
Tabes	1
	56

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ture. Some of the more significant of these complicating problems are listed in Table II.

MANAGEMENT

All but 13 (10 per cent) of the patients were admitted within forty-eight hours of injury.

TABLE III
OPERATIVE MANAGEMENT OF INTRACAPSULAR FRACTURES FIXED WITH SMITH-PETERSEN NAIL

	No Reduction	Closed	Open
26 Valgus	26	0	0
57 Mid-neck	0	24	33
47 Subcapital	0	7	40
	26	31	73

It was usually possible, therefore, to carry out immediate evaluation and treatment of the patient coincident with fixation of the fracture. Every hip fracture was considered an acute emergency demanding early treatment designed to minimize the period of pain and bed stay. Eighty per cent of the patients were operated upon within six hours of admission. In the presence of any systemic condition which increased the normal operative risk measures were taken immediately for its control or correction, e.g., a patient in fibrillation was digitalized as rapidly as possible and operation was usually done within six to eight hours. Otherwise, operation was usually performed within one to two hours.

Impacted valgus lesions were nailed without reduction or visualization of the fracture. All displaced fractures were reduced prior to fixation. Reduction was carried out under direct vision in seventy-three cases and under roentgenographic control in thirty-one cases. (Table III.) Subcapital oblique fractures proved the most difficult to reduce and frequently could not be reduced adequately by manipulation alone. Following operation, 65 per cent of all patients were allowed out of bed within twenty-four hours. Those physically able to use crutches commenced ambulation without weight-bearing in a walker about the fourth postoperative day and were promoted to crutches as rapidly as tolerated. (Table III.)

MORBIDITY AND MORTALITY

Morbidity cannot be described by measurable standards. However, it was observed in the cases under discussion that the morbidity constantly diminished in direct proportion to the speed and efficiency with which stabilization of the fracture was carried out. The mortality, Table IV, has been divided into three categories: "Operative mortality" includes

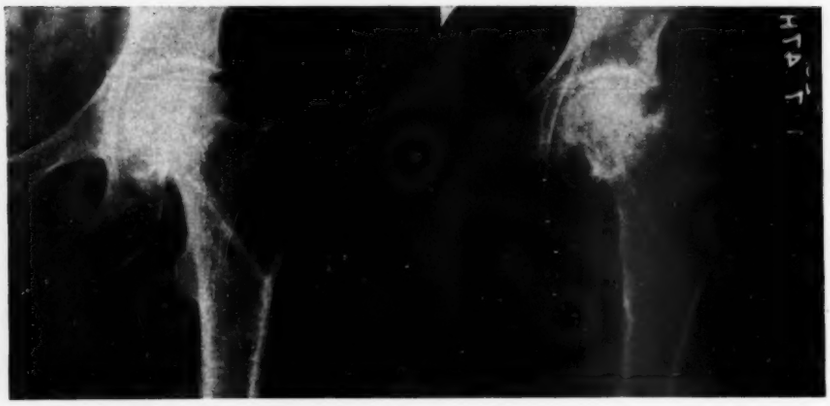
TABLE IV
MORTALITY

	No Reduction	Closed	Open	Total Per Cent
Operative	0	1	1	2 (1.5)
Related	0	0	2	2 (1.5)
Unrelated	1	2	5	8 (6.2)
No. of cases	26	31	73	130

deaths from any cause during the first thirty days following operation, e.g., one patient expired from pulmonary embolism twenty-eight minutes after completion of open reduction and another patient on whom a closed reduction and lateral nailing was carried out without adequate preoperative digitalization died in cardiac failure on the fourth day following operation. "Mortality related to injury" includes deaths related to the injury occurring within nine months of operation, e.g., one death at four months from pulmonary infarction secondary to thrombophlebitis and one at seven months due to infection of the hip and pneumonia. "Mortality unrelated to injury" includes all deaths from unrelated causes between the end of the first and ninth months, e.g., three cardiac infarctions, two cerebral accidents, one malignancy, one renal failure and one suicide. (Table IV.)

RESULTS

The incidence of bony union and subsequent avascular necrosis of the femoral head must constitute two of the more important features of any study of fractured hips. Identification of the former by adequate roentgenography should be definite. Aseptic necrosis, on the other hand, depends upon relative changes and is much more difficult to evaluate. A definition of terminology, therefore, is in order. Figure 2 illustrates the arbitrary distinction used in this study to differentiate between what will be termed "mild" and "severe" aseptic necrosis. Mild necrosis indicates avascular changes affecting only the roentgen texture of the



A B

FIG. 2. Aseptic necrosis; A, mild; B, severe.

femoral head. Severe necrosis indicates changes pronounced enough to change the shape or contour of the femoral head. The additional term "arthritic change" tends to confuse the issue and will be omitted. Many conditions described in other reports under the term arthritic change undoubtedly would fall into the category to be termed mild aseptic necrosis.

IMPACTED VALGUS FRACTURES

Early Complications. The twenty-six impacted valgus fractures presented no difficult therapeutic problems. (Table v.) The morbidity was mild. The average hospital stay was only fourteen days.

TABLE V
EARLY COMPLICATIONS—TWENTY-SIX VALGUS CASES

Mortality	0
Wound infection	0
Nail intrusion	3 (11%)
Hospital stay (average)	14 days
Weight-bearing (average)	5 months

TABLE VI
LATE COMPLICATIONS—TWENTY-SIX VALGUS CASES

	Per Cent
Adequate follow-up	23 (92)
Non-union	0
Mild necrosis	3 (11)
Severe necrosis	1 (3)

Late Complications. All twenty-six cases healed by bony union; however, contrary to popular belief, aseptic necrosis was not absent and occurred in 14 per cent of these patients. Three showed mild avascular changes and one developed severe aseptic necrosis. (Table VI.)

DISPLACED INTRACAPSULAR FRACTURES

The operative mortality in 104 displaced fractures was 1.3 per cent in seventy-three cases treated by open reduction and 3.2 per cent in thirty-one cases treated by closed reduction and lateral nailing. The operators consisted of all members of the staff from the most experienced attending to the least experienced resident surgeon. The duration of the operative procedures, therefore, varied considerably. However, closed reduction and lateral nailing constantly required more time than open reduction and nailing under direct vision. (Table VII.) It was also a constant observation that (1) regardless of the characteristics of the fracture, reduction and fixation were accomplished more certainly and accurately when carried out under direct vision and (2) this unselected group of patients withstood the effects of open reduction as well if not better than manipulative reduction and blind nailing.

TABLE VII
OPERATIVE TIME AND MORTALITY

	Operative Mortality, Per Cent	Time (Anesthesia to Skin Closure)
73 Open reduction	1 (1.3)*	1 hour, 53 minutes
31 Closed reduction	1 (3.2)†	2 hours, 19 minutes
104 cases	2 (1.9)	

* Embolus.
† Cardiac (not digitalized).

Early Complications. The oblique subcapital fracture with a vertical fracture line deserves recognition as a complication in its own right.

Its presence made both reduction and fixation more difficult than in any other type of hip fracture. Because of this, it has become our policy of operative technic to modify such a lesion so that the line of fracture would approach the horizontal plane. When necessary, this was done by primary cervical or trochanteric osteotomy. In addition, many apparently satisfactory reductions by x-ray[2] proved inadequate on visual inspection of the fracture line. Consequently, arthrotomy was found to be essential for optimum reduction and stabilization of almost all subcapital fractures. There was little or no difference between open and closed reductions in the incidence or effect of postoperative infections. During convalescence 12.5 per cent of 104 displaced fractures were complicated by loss of fixation. Almost invariably this complication resulted from faulty technic of nail insertion or reduction, and frequently both. (Table VIII.)

TABLE VIII
EARLY COMPLICATIONS—104 DISPLACED CASES

	73 Open, Per Cent	31 Closed, Per Cent
Subcapital fracture	40 (55)	7 (22)
Poor reduction	11 (15)	14 (45)
Infection—serious	1	0
—trivial	6 (8)	3 (10)
Loss of fixation	11 (15)	2 (7)

Non-union. Poor reduction or fixation also accounted for the great majority of non-unions. (Table IX.) However, improper placement of the nail resulted in disaster for three well reduced cases. Early severe aseptic necrosis prior to bony union occurred only once, suggesting failure of local blood supply to be a relatively unimportant cause of non-union when compared to inadequate restoration of anatomy. Two uncooperative patients were considered to have contributed to their non-unions by early and strenuous unauthorized weight-bearing on the injured leg.

Avascular Necrosis of the Femoral Head. The interval between operation and the first evidences of aseptic necrosis has resulted in the adoption of eighteen months as the minimum adequate follow-up period. Periodic clinical and roentgen examinations for at least this period were possible in seventy-four (71 per cent) of the 104 displaced fractures. (Table X.)

Table XI includes only those patients with bony union and an adequate follow-up. Forty-two per cent of healed fractures treated by open reduction and 54 per cent of those treated by closed reduction and lateral nailing subsequently went on to show aseptic necrosis of the femoral head. The first evidences of all severe avascular lesions were apparent within nine months of operation. The first evidences of mild lesions often did not occur until after one year. Twenty-six months was the longest and eleven months the average interval between operation and demonstrable early avascular changes. It is worthy of note that in spite of the much higher proportion of subcapital fractures in the open reduction group, (Table VIII) the incidence of aseptic necrosis in this group remained consistently less than in the simpler cases treated by closed reduction. This finding contradicts the widespread impression that open reduction contributes to avascular necrosis subsequent to fracture of the femoral neck.[3,4]

TABLE IX
CAUSE OF NON-UNIONS—104 DISPLACED FRACTURES

	73 Open (55% subcapital)	31 Closed (22% subcapital)
Poor reduction	11	4
Poor fixation	2	1
Failure of circulation?	1	0
Walked too soon	2	0
	16	5

Note: 72 per cent non-unions were in subcapital fractures.

TABLE X
FOLLOW-UP

	73 Open	31 Closed
1.5 to 3 yr	21	5
3 to 5 yr	16	5
5 to 8 yr	9	5
8 to 12 yr	8	5
	54 (74%)	20 (65%)

MUSCLE TRANSPLANT SERIES

Between the years 1933 and 1937, eighteen intracapsular hip fractures were subjected to open reduction and coincidentally a flap of rectus femoris or vastus lateralis muscle was inserted into a decorticated area on the anterior surface of the head and neck of the femur. It was hoped that this might increase the local blood supply to the head fragment.[5] Thirteen cases in this series were suitable for analysis. (Table XII.) Their results warranted little optimism that the procedure was of any help in preventing aseptic necrosis or of any aid in the healing of the fracture.

TABLE XI
NECROSIS FOLLOWING UNION
18 MONTHS OR MORE FOLLOW-UP

	Mild, Per Cent	Severe, Per Cent
Open reduction—38 cases	9 (24)	7 (18)
Closed reduction—15 cases	4 (27)	4 (27)

TABLE XII
THIRTEEN MUSCLE TRANSPLANT CASES

Mortality	0
Infection	0
Nonunion	3 (23%)
Necrosis following union—mild	2 (20%)
—severe	0

EVALUATION

The preceding discussion has been restricted to an objective study of a group of patients with fractured hips. The results, Table XIII, are discouraging and humbling from the viewpoint of the surgeon. Almost every poor surgical result was found to be due to some controllable defect in the technic of therapy. Consequently, the percentage of good results was considerably less than should have been obtained. Realization of this fact during recent years has stimulated insistence upon perfection in each of the numerous finer details of technic. It seems reasonably certain that only by perfection of technic can the incidence of non-union and aseptic necrosis be reduced to justifiable levels.

TABLE XIII
SUMMARY OF RESULTS

		73 Open, Per Cent	31 Closed, Per Cent
Mortality	Operative	1.3	3.2
	Related	2.6	0
	Unrelated	6.8	6.5
Non-union		21.9	16.1
Aseptic necrosis		42.0	54.0

TABLE XIV
PATIENT'S EVALUATION VS. SURGEON'S EVALUATION

	73 Open, Per Cent	31 Closed, Per Cent
Patient satisfied	86	92
Surgeon satisfied	25	20

Patient reports on the results of hip fractures are misleading. The functional demand placed upon an extremity by a patient in this age group is usually small. Many such patients are satisfied with an unnecessarily poor surgical result. Table XIV indicates clearly that accurate evaluation can only be obtained by periodic clinical and roentgen examinations over a protracted period.

CONCLUSIONS

1. The best time for reduction and fixation of a hip fracture is immediately.
2. Good treatment for impacted valgus fractures of the femoral neck is internal fixation and avoidance of bed stay.
3. Open reduction, properly done, is surer, shorter and no more dangerous than closed reduction and blind nailing.
4. Open reduction does not increase the incidence of subsequent aseptic necrosis.
5. Results are known only after objective evaluation.
6. Almost all of the bad results of hip nailing are still the results of bad hip nailing.

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DISCUSSION OF PAPERS BY DRS. HARMON, BAKER AND RENO, GALLAGHER AND NEER AND MCLAUGHLIN

Kellogg Speed (Chicago, Ill.): Honest observation and tabulation now show that nailing either by the so-called blind or open reduction method has an astounding percentage—not of non-union as it used to be called but now with effort at bony union and of the more advanced and scientific term of aseptic necrosis of the head from interfered with vascularity. The extremely oblique fractures of the neck are most difficult to reduce, to hold reduced and to obtain bony healing without separation of fragments or early aseptic necrosis. I have wondered for years just how important the terms intracapsular and extracapsular fracture were from a prognostic standpoint because we are shown in McLaughlin's series that open reduction of the fracture near the head finally give a lower percentage of aseptic necrosis when one might think that by open dissecting methods more blood supply to the already exsanguinated head would be lost.

The process might be summarized thus: The fracture is reduced and nailed properly with full attention to all technical details by earnest qualified surgeons; a certain and quite large percentage have suffered from interference with blood supply to the head which occurs at the instant of fracture. In addition there may be untoward trauma from the nail or screw insertion or the forceful impaction of the fragments after internal fixation as mentioned by Harmon. He found that the highest holding power of head to neck obtained by Geckler screws or hexagonal headed stainless steel screws was so powerful that the maximum holding power obtained exceeded the maximum force required to pull the head of the femur from an unfractured femur. This looks like real bony approximation and fixation which we know has its virtues in the bone healing after fracture but this also must be aided by physiologic rest. The accurate nailing and primary freedom from weight bearing give us some misleading roentgenograms. Rapidly occurring aseptic necrosis of the capital fragment is neither early nor quickly recognized. With a good reduction and freedom from weight bearing, replacement of bone in the head starts early and may progress favorably, again fooling us in the roentgenogram. Eventually comes the unlucky or unhappy day when weight bearing is permitted, often after full roentgenologic confirmation which may be based on wrong interpretation. If the head has partially undergone Axhausen's creeping substitution, it may hold up for awhile but eventually begins to buckle with collapse of subcortical bone and finally cartilage warping and fragmentation although some cartilage may maintain nutrition for a long time from synovial fluid feeding. This becomes what we call clinically delayed or late aseptic necrosis but it probably is not any slower pathologic process at all than those which break down quickly, deform and cause disability because of too early weight bearing or unhappy axial replacement of fragments. The fracture of this rather soft and partly unsubstituted bone of the head after apparent bony healing with crushing of its cartilage is now advanced by Phemister as a second phase in untoward progress. Not only are six to nine months' time advisable for freedom from weight bearing to avoid this but in some instances two, three or more years are required. This leads us around in a circle again to the unsolved fracture. Must we treat a fracture of the neck of the femur even after accurate nailing with the most meticulous technic as we would a Legg-Perthes' disease in the adolescent, or should we devise some more searching view by the roentgenogram to enable us to distinguish aseptically necrotic bone quicker and better, or must we adopt some method of increasing or assuring a greater and more satisfactory blood supply to the poor capital fragment. You have heard the opinion of muscle flap transplantation advocated by Venable and Stuck. Many more instances of this procedure must be tried before final condemnation of its routine use but on the whole it does not sound physiologic. Muscle flap deprived partly of full and normal nerve and blood supply and physiologic use in the general direction of its fibers as intended naturally probably in a short time becomes a simple mass of fibrous tissue without much vascularity.

We must therefore study additional series of healed fractures at the neck of the femur treated by a meticulous technic of one method or another. Let us devise quicker and better methods of determination of aseptic necrosis of bone; let us revert to elementary principles in fracture treatment and use immobilization and freedom from strain of weight bearing and functional use until a natural healing or a natural replacement of devascularized and dead bone has occurred. Secondary and late so-called arthritis of the hip, reaction to a dead head with crumpled and undermined cartilage may then not develop in the hip joint as an irritant reaction.

The holding powers of the various types of metallic internal fixation agents are important only so far as they assure immobilization, absence of electrical and biochemical reaction and do not permit neck angulation nor interference with

creeping substitution in bone. I cannot see that removal of the fixative agent aids the final healing of the capital fragment fracture if the metal is inert biochemically. Reported series of bone transplants really show no better final results. Small chip or fragment onlay grafts onto the exposed neck may be biologically superior and lead to final bony substitution and restoration of a withstanding weight bearing upper end of the femur. If need be, they may be put in early at operative reduction to be followed by weeks of plaster immobilization. All these processes of repair require considerable time and some patients may succumb during the process.

RALPH G. CAROTHERS (Cincinnati, Ohio): I had not before considered the distracting force of any importance in these cases and it was interesting that Dr. Reno brought it out. However, I still believe it is not of so much importance. I noted in his pictures that his pins were put in so that they were not parallel; in other words, they crossed very much like the pictures of the original Moore articles. That will prevent distraction in itself, far better than a Smith Petersen nail, but the important thing to remember is that there is absorption of the neck in a great many of these cases and it is important that the outer fragment be permitted to slide in upon the inner fragment and maintain contact. Therefore, I believe the pins should be put in absolutely parallel or as nearly so as possible.

I have used the three pins rather than the Smith Petersen nail, but by putting them in parallel one simulates the three blades of the nail.

I think that in Dr. Gallagher's remarks about nailing causing a disruption of an already good impaction, that it does not hold if one uses these finer pointed pins rather than a larger Smith Petersen nail, and it has been my practice to nail these impacted fractures for the purpose of getting the patients out of bed and away from the hospital sooner.

Dr. Speed's remarks remind me of a case which occurred in our own family this last winter. An old lady had an intertrochanteric fracture of the neck of the femur which I elected not to pin but to put in traction. She obtained an excellent result and is now home and walking around quite well. It cost over $6,000 for hospital and nurses. That is getting into figures that most people cannot afford, and even the government cannot keep us all too long. Therefore, something has to be done to get them going and quite early.

I am interested in how easy it seems to be to do the open reduction procedure. When Dr. Smith Petersen first presented this subject fifteen or more years ago, he performed a very large and glorious operation. I was impressed with the fact that 90 per cent of the patients I had could not have stood such an operation. Dr. Smith Petersen's pictures were of fairly young, thin women who would walk up and down the steps to show how well they were afterward. My patients were old and feeble ladies and my nailing was on account of that. Now, apparently, we are going back to the other method, but I still have a large number of people who I do not believe could stand the open type of operation.

WALTER G. STUCK (San Antonio, Tex.): In most discussions of fractures of the hip there has been too much emphasis placed on getting the patients out of bed. These old women are not going anywhere. Many of them are feeble, most of them are glad to throw themselves on the mercy of their relatives and to get them out of bed a day or two after the accident seems an unnecessary procedure. The articles which show pictures of patients who had a fracture a few days before and now are riding around in a wheelchair are spectacular but that is all.

In bed these patients can roll around, sit up, be turned on their face and have ample ventilation of the lungs. Also this bed exercise is better for circulation of the extremities than sitting motionless in a chair. They can leave the hospital and stay in bed at home without great expense. If the patients are kept in bed for a minimum of eight weeks and on crutches for a minimum of six months, the incidence of aseptic necrosis will be minimal.

I have just finished a study of a series of traumatic dislocations of the hip in which I found that the patients that had associated injuries, such as fracture of the shaft of the femur or tibia which compelled them to stay in bed, ended up with excellent hips. On the other hand, those patients who got up early and bore partial weight with crutches developed aseptic necrosis. I think the same thing obtains in the fractured hip cases. As Dr. Carothers mentioned many of these patients are senile, frail old women and if they are placed in a walker on the fourth or fifth postoperative day, it is hard to believe that they do not occasionally bear full weight on the affected limb.

As to the question of the open operation John Fahey of Chicago has demonstrated very beautifully in injection specimens that the main blood supply to the head of the femur comes through the posterior capsule so there is no harm in incising the anterior capsule. The original Smith-Petersen operation involved opening the whole hip joint by an anterior approach and then inserting a nail through a lateral exposure of the trochanter. Use of the single lateral incision is no more shocking than the so-called blind nailing. A quick operation by direct exposure of the fracture is less strenuous than a long "blind" procedure.

Perfect reduction of the fracture, complete immobilization of the fragments with internal fixation and prolonged protection of the hip against

weight bearing will do more than anything to eliminate late aseptic necrosis of the head of the femur.

ESLIE ASBURY (Cincinnati, Ohio): Each one of the speakers has made a direct contribution, and from the discussions and the papers it seems that a good many more of us are going to have to make a good many more contributions before we will be satisfied with our results in these cases.

I think Dr. Cubbins made one of the more important points on this subject some years ago. He pointed out the absolute inevitably bad result that must occur in such a high percentage of these cases. Therefore, people who get terrifically high percentages of bony union without too high percentages of aseptic necrosis must be lucky in the cases that come to them.

In the first place, they would be fortunate in that they did not work in a charity hospital in a big city where they had a great many people with malnutrition and with possibly other advanced and neglected conditions. People who practice in the prairie country or the farming districts where the women are more active and out-of-doors and in better general condition will certainly have a much higher percentage of good results.

The whole thing depends upon not the method used but the adequacy of the method and the absolute realization in a very early period in the treatment of some of these cases that you are going to get a bad result with the method you are using.

Dr. Neer brought out the oblique fracture as one of the situations. As one of our New York members showed last year the messed-up case, that is, one requiring removal and replacement of nails or screws, probably should not be nailed but an osteotomy done as a primary procedure. People who have very bad bone, who have very friable bone that will not hold nails very well and those who we can see from past experience are going to give us inevitably bad results should have an osteotomy as soon as possible.

FRANK P. STRICKLER (Louisville, Ky.): I think it is well for some of the older men who were trained with Dr. Royal Whitman and Sir Robert Jones to discuss these papers as we have seen large numbers of fractures of the neck of the femur and are well acquainted with the development of the surgical treatment of this fracture also with all of its trials and tribulations. We must realize that we had aseptic necrosis of the head and neck of the femur before we ever nailed a fracture of the femur or introduced a foreign body into the head and neck of the femur.

Dr. Royal Whitman introduced his reconstruction operation to overcome the results of aseptic necrosis of the head and neck of the femur and also kept his patients at rest in a spica for three months and that in spite of rest and fixation, aseptic necrosis did occasionally develop with the Whitman treatment.

We should remember that these patients are on the downhill side of life with all sorts of medical complications, lowered vitality and an impaired metabolism. They may have impaired circulation in the head and neck of the femur at the instant the fracture takes place, and if you start with a bad circulation you have an excellent opportunity to end with aseptic necrosis of the head and neck of the femur. In my opinion the end results will depend on whether the original circulation was good, bad or indifferent.

If there ever was a fracture in which we need a medical consultant, it is in fractures of the neck of the femur and I always have a medical man to help me on these cases. The patients are sick and debilitated to start with and there are all kinds of medical complications to meet. These patients require special diets, high in calcium and proteins, with vitamins, fruit juices, green vegetables, etc., and the medical man is the one to see that they get this attention. We have to consider the patient as a whole, along with his body chemistry, not just the fracture of the neck of the femur and the kind of nail we are going to use in the operation.

I have been nailing fractures of the neck of the femur for a good long time, and I have finally settled on the Smith-Petersen nail. We nail these fractures on a Hawley table, first reducing the fracture under x-ray control, taking anteroposterior and lateral x-rays. We use pentothal and oxygen anesthesia. We never use guide wires. I do not think the trauma caused by introducing these guide wires improves the circulation in the head and neck of the femur; besides, they are not at all necessary. If you know where the head of the femur is and how to drive a nail, that is all there is to the procedure. We use a large drill, slightly smaller than a Smith-Petersen nail, to get through the cortex just below the trochanter; then with two fingers and a sense of touch the job is done in thirty-five to forty-five minutes, including the x-ray check-up. Let me repeat again, guide wires are not necessary and these wires do cause a lot of trauma and do undoubtedly interfere with the circulation. I know of cases in which six and eight of these wires have been put into the head and neck of a femur. This also requires time and unnecessarily prolongs the operating time.

We put our patients to bed without fixation of any kind; sometime we may use a sandbag. The patient is kept in bed until the wound is healed and there is no danger of infection, then the patient is gotten up in a wheel chair, next a walker and at last crutches. We all know that it takes about one year for these patients to completely recover; however, the patient is usually walking in three weeks.

Everyone who has been in surgery or medicine for any period of time knows that elderly patients do not do well if left in bed any prolonged length of time; they become confused mentally, their appetite is impaired, they have chest complications and they are beset by all the ills they had previous to the fracture and the desire to recover is soon lost. It is not showmanship to get these patients out of bed, but good common sense. In my opinion the sooner you get these patients out of bed on a well regulated diet and under the care of a good medical man the sooner you are going to get much better results.

Some of these patients can not be nailed at once; some of them are in severe shock and have medical complications that delay the operation. This also applies to many other fractures. The whole subject of fractures is being treated entirely too casually by many doctors. Fractures are a serious, costly business. They should not be taken as soon as they enter the hospital and put on an operating table while they are still in shock and have a thoughtless surgeon put thirty to fifty sutures in a scalp wound, many times without even a local anesthetic, when the scalp wound is of secondary consideration and can be sutured at any time.

Recently in two large teaching hospitals, I know of an extensive fracture of the pelvis that was not found in a seriously injured patient. Another instance I know of was a small boy with a fracture of the middle third of the femur who was put to bed for forty-eight hours without a splint or traction. Instances of this sort should not occur in teaching hospitals.

JOHN E. CANNADAY (Charleston, W. Va.): Not sufficient attention is being paid to restoring circulation to the fractured neck of the femur in these intracapsular fractures. I have noticed in recent reports from Norway, also from the Cleveland Clinic, the increasing use of the crest of the ilium for bone pegging, also that fragments of iliac bone are being used successfully to restore circulation to the detached head of the femur, likewise to promote union in the fractured os calcis.

BOARDMAN BOSWORTH (Bronxville, N. Y.): Dr. Strickler has stolen much of my thunder. It does seem to me that the whole history of the development of the treatment of fractures of the neck of the femur entirely refutes Dr. Stuck's position, with all due respect to Dr. Stuck.

We started with traction, then with the Whitman abduction spike, then with nails, pins and what have you for internal fixation. The whole purpose of each of them was a step forward toward mobilization of the patient, purposely so designed because of the type of patient you were dealing with, the age level in which he fell, the complications which were to be expected in a patient of that age and degenerative conditions at that time of life.

It does seem to me, in agreement with Dr. Strickler, that we have to think primarily of the patient as a patient whom we want to replace as nearly as possible in her previous condition and as quickly as we can do it.

Why should we put a patient to bed and keep her in bed for eight weeks when all she has is a simple fracture of the neck of the femur which can be held in position perfectly adequately by some form of internal fixation? It does not matter which you choose. I grant you that the patient should be individualized. There will be certain of these patients who will have bad cardiac conditions, but if they do not have those restrictions then I am all in favor of getting them out of bed, not as a spectacular gesture, but for the sake of a live patient.

J. T. F. GALLAGHER (closing): I want to thank Drs. Speed, Carothers, Stuck and Asbury for their helpful suggestions. I might add that in the past eighteen months our postoperative care has been radically changed. No patient is allowed weight bearing for three or four months, and they all wear walking calipers for one to one and one-half years. Although it is too early to draw definite conclusions, the end results to date in this series are far more favorable.

MANAGEMENT OF WAR INJURIES TO PERIPHERAL NERVES

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THE purpose behind this series of papers dealing with the handling of special types of war casualty cases is to frankly evaluate the faults in the methods adopted in the last war, with a view to bringing out constructive suggestions as to the handling of such cases in the event of another war. It must be realized at the outset of this discussion that each one of us saw but one small segment of a most complex situation so that the criticisms we may voice may be unfair to the overburdened authorities against whom they appear to be directed. We must also realize that the faults as we saw them in the last war belong in two categories, in only one of which could our opinion be considered authoritative. The first category includes the faults inherent in any military regimen suddenly called upon to deal with large numbers of wounded men after a long period of relative stagnation during peacetime. The second category covers those faults applicable to the handling of particular kinds of war injury. Perhaps we should confine our discussion to this latter category of faults which involve our own specialty fields. Yet the two categories are so intimately related that it is impossible to consider one without regard to the other.

Although each of us represents a different specialty in the field of surgery, we had one experience in common. At the termination of the war each of us was fortunate enough to be handling the particular type of patient which our training and experience best qualified us to treat. We had reason to believe that we were contributing to better end results in these cases. We were justifiably proud of the fact that our efforts might well lessen the permanent disability for these wounded men and proportionately diminish the economic burden that they would ultimately impose on society. The principal regret that each of us had in this culminating phase of our war experience was that the improved care of these surgical problem cases had not been instituted at an earlier date. The essential question with which we are concerned today is how the delays and faults we encountered in the last war might be lessened or eliminated in future wars. I believe that the best approach to this question is to relate our individual experiences and by pooling our impressions we may be able to agree on valid criticisms of past procedure and, from these, constructive suggestions may emerge.

During the greater part of the war our Naval Hospital acted as a receiving hospital through which great drafts of men poured from the Pacific area to be distributed to other mainland hospitals. The wounded were handled in drafts, and not infrequently the hospital admitted more than 1,000 new patients in a single day. At the peak of our load in 1944 there were 57,000 new admissions which meant approximately a complete turnover of our full bed capacity each month. There were times in which we had a serious shortage of medical officers to handle these wounded men. Yet within a few miles of us were two great camps in which hundreds of naval medical officers were marking time while they waited for orders from Washington. Among these men were many specialists whose services would have been invaluable to us and hundreds of younger men eager for the hospital experience we could have offered them. These medical officers "stewed in their own juices" for months at a time and no one in our naval district had the authority to give these men temporary assignments or to see that when they received orders from Washington the duty was such as to fit their particular talents.

The waste of special talent was also apparent within the hospital itself. Not only was there insufficient clerical help on the wards, but nurses, corpsmen and Waves were constantly changing. Proper care of those with peripheral nerve injuries requires special skills, and no sooner did one of these persons begin to acquire that skill than they were moved elsewhere. The need for special training was even more obvious among the medical officers assigned to help with the work on our wards. Not only was

special skill needed in the surgical treatment of nerve injuries, but in the study of these cases upon which decisions as to treatment and prognosis must depend. For the first half of the war the average stay of these young medical officers on my ward was less than one month. In addition, the necessity for filling the outgoing drafts required that we ship out nerve patients regardless of the stage of their investigation and treatment.

In the final phase of the war this grim picture changed considerably. Much of this change was due to the efforts of our commanding officer. He appreciated the improved care of surgical problems that could be afforded on the specialty wards, and he made every effort to provide the specialists with the equipment they needed and to assure some continuity of service in personnel. There was also evidence that the Bureau of Medicine and Surgery in Washington was becoming aware of the specialty care of surgical problems. Centers were established to which particular kinds of cases were to be assigned; young medical officers were sent to these centers for training and with some prospect of greater continuity of service and greater efforts were made to supply the centers with the equipment and personnel that they needed. Our hospital was designated as a center for peripheral nerve injuries, and in a small measure we were able to carry out parts of the program for their care that had been so well established by the British. In my opinion neither the Navy nor the Army ever approximated a full implimentation of the excellent British program for the handling of nerve injuries. And the sad commentary on the British plan was that it was available to our military authorities in its complete form before the United States entered the war.

To return to the problems peculiar to nerve injuries we learned something about them even during the difficult and confused early phases of the war. At this time the lack of transport delayed evacuation of wounded men from the Pacific area to the mainland hospitals for long periods. Even during the second year of the war the time interval between wounding and admission to our hospital for these nerve patients averaged five and one-half months. In this interval most of the men had been moved from one hospital unit to another, rarely staying long enough in one place to permit adequate investigation or treatment. This long delay was certainly regrettable, but it taught us two lessons which might otherwise have escaped attention.

First, we were surprised to find that after months of complete nerve paralysis some of our patients were showing signs of spontaneous recovery of function. In certain of these cases one could feel a neuromatous enlargement of the nerve trunk near the level of wounding, and yet both sensory and motor function were already well established distal to the local lesion. High velocity missiles release enormous energies in their wake which tear or stretch nerves to produce disruption of nerve fibers without actual interruption of the nerve trunk. Our observations indicated that in a considerable number of "lesions in continuity" a spontaneous recovery of function occurred that was more complete than a surgeon could hope to confer by resection of the local lesion and end-to-end suture of the nerve trunk. Yet I am convinced that had we explored these patients while their paralysis was complete we would have resected the local lesion. Unless we had seen for ourselves how complete spontaneous regeneration may be through many of the lesions in continuity, I know that we would have resected many of them without ever questioning the advisability of this procedure. These observations led us to be very conservative in the treatment of any nerve lesion in which there was any reasonable chance for spontaneous regeneration.

A second lesson that the last war taught was that attempts to repair surgically nerve injuries immediately after wounding are ill advised. The British have clearly shown that entirely aside from the hazards of infection and inadequate surgery in the front areas, the end results are better after *early secondary* repair of nerve lesions than after immediate repair. The optimum time for nerve suture seems to be three or four weeks after a nerve has been severed although under war conditions any time within the first three months could properly be considered as early secondary suture. These facts have a bearing on the handling of nerve casualty patients, in that it does not seem to be imperative that trained surgical teams operate in the front areas. These patients could be handled by general surgeons exactly as are those with wounds uncomplicated by nerve injury except that a

careful record should be made as to the exact status of the sensory and motor findings during this early period of observation. If good records were kept, there would be no necessity for giving nerve patients a high priority in being evacuated so long as they reached a center designated for their care within the first month or two after wounding.

The delay that occurred in evacuating the wounded to mainland hospitals in the last war tau ht one other lesson which was that plaster casts should not be used to support paralyzed muscles in the uncomplicated case of nerve injury. Our medical officers had been taught that all paralyzed muscles should be supported to prevent overstretching and contractures. Since light splints were not available to them, they used plaster casts. In the months that elapsed between wounding and the time these men reached us they wore these plaster casts continuously. They were moved so frequently from one hospital unit to another that no one had time to investigate them well and as long as the plaster cast was reasonably comfortable and rigid it was left on. If it had to be removed for some reason and the paralysis was stili present, a new cast was applied. By the time these men reached us the muscle atrophy and joint stiffness resulting from the long period of immobilization were often of as serious consequence as the nerve lesion itself. The first standing order issued on the peripheral nerve wards of our hospital was that all plaster casts must be bivalved within twenty-four hours of the patient's admission. It was most unusual to find any justification for a re-application of a rigid support. Active use of the affected limb was of such importance in these cases that we seldom used even the lightest splints. In fact, our staff came to doubt the advisability of routine splinting for any uncomplicated case of peripheral nerve injury. I shall not attempt to justify this view here, but there can be no argument over the fact that rigid immobilization of paralyzed muscles for extended periods can do much more harm than no splinting at all.

There are other problems relating to the surgical handling of peripheral nerve injuries which might be mentioned, relating to suture material, grafts, protective sleeves, prognostic testing and the like, but these are technical problems which have no place in this group discussion. If specialty patients are segregated and are placed under the care of properly trained medical officers, these questions will answer themselves. The point which we must emphasize is that prewar planning must provide for such segregation and the delegation of sufficient authority to the specialist to enable him to give his patient adequate care. I am aware that certain reservists are cooperating with the military authorities in the Medical Corps of both the Army and the Navy in making prewar plans and that a few medical officers in active service are being certified by the specialty Boards. An authority has told me that, "as soon as a war is declared and mobilization well under way, the qualified specialists in the Navy and among the Reserves will automatically get together and decide upon an over-all plan from the time the peripheral nerve is injured until rehabilitation is complete." Personally, I have no faith in this optimistic prediction. There is no way for specialists to "automatically get together" unless this is arranged for as part of a definite plan, and even if they are successful in getting together it is to be doubted that they will have the authority to impliment their recommendations. Once mobilization gets under way these men will again be lost in the shuffle and their efforts will be effectively stifled by superior officers who have neither insight into specialty problems nor tolerance for the specialist. Unless there is a definite prewar plan for the handling of specialty patients and some alteration in the general attitude toward the specialist among the regulars, I predict that we will witness the same waste of surgical talent which was so distressing in the last war. If I were to list the things which I think prewar planning should provide for as a minimal provision for the handling of peripheral nerve injuries, these would be included: (1) The establishment of centers for the special care of peripheral nerve injuries. These patients should be evacuated from the front areas to a center as soon as possible after the more critical casualty patients have been cared for. (2) Provide that each nerve patient be sent to the mainland center nearest his home and keep him there until his final disposition. (3) Put the best available specialists in charge of these specialty patients and provide them with the equipment and assistance they need for efficient service. (Adequate assistance should include clerical help.) Strictly medical decisions relat-

ing to patient care should be in his hands even though ward responsibility may be shared by less well trained officers of higher rank. (4) Give these centers the responsibility for training young medical officers in specialty work. Give these trainees sufficiently long term assignments to this duty to assure continuity of service. (5) Provide for the patients vocational training, recreational facilities, and a liberal "leave" policy. Peripheral nerve patients have long periods between stages in surgical treatment during which hospitalization is not a necessity. Judicious use of extended leaves tends to maintain good morale and to make additional beds available. (6) Last, but not least, abolish the saying, "You are a Naval Officer first, a doctor second, and a specialist last, if ever" as well as the attitude which such a statement connotes.

It is this last point that I would like to amplify in my closing comments. I think the specialists from the medical reserve did a fine job in World War II. I am willing to believe that the military authorities recognized this service in the last few months of the war and were sincere when they tried to get many of these men to remain in active service. If the authorities in Washington had been a little less set in their ways and willing to give assurance that these men would be retained in their specialist capacity to care for patients, to train young medical officers and to have an active part in prewar planning, some of these men would have remained in service no matter what personal sacrifice it might have entailed. But in the absence of any such assurances and with no reason to believe that the prewar planning would be any more apt to conserve medical talent than it did in the last war, the self-respect of these men demanded that they leave active service. It is exactly these same considerations which have influenced most of these men to resign their commissions in the reserve corps. I am convinced that these resignations are not a sign of lack of patriotism. I am sure that if another war should come these men will be back in service, but they believe, and I for one believe they are justified in this feeling, that their chances of getting an assignment for which they are particularly fitted would be better if they were completely outside the reserves than if they retained their commissions.

I am confident that there are many specialists formerly in the reserves who could be persuaded to undertake the training of medical officers in their special field of surgery right now, and I am sure that many of them would be glad to assist in prewar planning, at least insofar as the handling of special types of patients is concerned. To enlist their aid should require little more than good evidence that the regular's attitude toward the specialist had undergone a change, and an assurance that what they helped plan for in the event of another war would have a reasonable chance of accomplishment.

HANDLING OF TRAUMA IN THE UNITED STATES NAVY*

REAR ADMIRAL ARTHUR H. DEARING
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THE actual treatment of traumatized individuals in the Navy does not differ greatly from such treatment in civil medicine. It is in the factors that govern this treatment, the environment in which it must be carried out and the large number of war casualties which flow to the hospitals that differences exist.

In peacetime the treatment and organization for treatment of trauma in the naval service is not unlike any far-flung industrial organization. There are well equipped dispensaries at the large Navy Yards and shore stations with excellent hospitals nearby to which the injured man or woman may be sent if hospitalization is needed. The same situation exists at our large overseas naval bases. At smaller bases, if no hospital is present and treatment is beyond the facilities and equipment of the medical officer present, air transportation provides easy and rapid transit to a hospital. Large concentrations of ships afloat and away from our coasts usually have with them a completely equipped hospital ship. Solitary ships anywhere in the world can quickly obtain the specialized services of a skilled medical officer and rapid transportation to a modern hospital in this day of radio and swift air transport. As a matter of fact the Naval Air Transportation System maintains regularly scheduled hospital flights on a worldwide basis. The bluejacket injured in an accident aboard a ship in the Mediterranean may be in a Naval Hospital in New York or Philadelphia within seventy-two hours after injury.

However, it is in time of war that conditions exist and factors come into play that complicate the treatment of casualties, necessitate an elaborate organization for such treatment and profoundly influence all personnel involved in treating casualties and the end result as far as the patient is concerned. Thousands of doctors came in contact with these factors during World War II and were influenced by them; some were irritated by them, a few never understood them but the vast majority accepted the conditions imposed by war. The results speak for themselves for our recovery rate was higher than in any war—98 per cent of the wounded survived.

The first objective in the treatment of casualties in the Navy as anywhere is to save life. That comes first, save the man's life. The second objective is to heal his wounds as rapidly as possible, effect his rehabilitation and get him back to duty, aboard ship, at a Naval Station, in a Marine Regiment, at an air station or wherever he is needed, but get him back on the job to do his part as a trained sailor or marine to help defeat the enemy.

The prime factor which influences the surgery of trauma in the Navy during war is the necessity for frequent transfer of the patient from one hospital and the care of one surgeon, to another hospital and another surgeon. This goes on from the time the man is injured aboard ship or in the field until he reaches the hospital where his treatment and rehabilitation are completed. This necessity to transfer the patient from professional hand-to-hand is the direct opposite of civilian life when the individual who is injured is usually placed under the care of a surgeon within a very short time after the injury and almost invariably continues under the care of that individual surgeon until his recovery is complete. It is the organization to accomplish this movement and to ensure continuity of treatment that was developed and improved in World War II.

The surgery of trauma in the Navy during World War II may be divided into two categories: First, trauma occurring at sea aboard ship and second, trauma ashore as seen particularly in the Marine Corps which is an integral part of the Navy.

CASUALTIES AT SEA

One characteristic of naval warfare as distinct from land warfare is that the number of killed equals or exceeds the number of wounded. (Table 1.) This may not hold true for an indi-

* The opinions and views contained in this article are those of the writer and are not to be considered as reflecting the policies of the Navy Department.

vidual engagement or ship but in the aggregate it still holds. It is due to such factors as the confinement of personnel in closed spaces aboard ship where fire, blast and explosions kill all hands, immersion, drowning, etc. Paradoxical as it may seem in Naval warfare the

TABLE I
CASUALTIES DUE TO ENEMY ACTION, U. S. NAVY, DECEMBER 7, 1941 TO DECEMBER 31, 1946*

Method of Disposition	Navy		
	Total	Officer	Enlisted
Total	68,897	6,684	62,213
Killed in action	34,625	3,655	30,970
Died prisoner of war	891	134	757
Wounded:			
Died subsequently	922	66	856
To duty	27,784	2,784	25,000
Invalided from service	4,558	30	4,528
Deserted	6	.....	6
Disposition undetermined †	111	15	96

* Source: "K" file card, "Individual Statistical Report of Patient"; data are provisional as of July 1, 1947, date of compilation.

† Includes patients remaining on the sick list (319 as of July 1, 1947), and those whose records are lost or otherwise unavailable; no deaths are included in this total.

opponents are seeking to destroy the ships and their usefulness rather than directing their main efforts toward killing personnel. In land warfare, where the wounded always greatly exceed the killed, the opponents attempt to kill personnel rather than necessarily destroy material. (Table II.)

Certain types of trauma are more frequent aboard naval ships due to the pecularities of naval warfare: Burns are usually present in large numbers due to the flash of exploding shells and bombs, escaping steam from ruptured lines and fires generated by the heat of explosion. Fractures of both lower extremities and the spine are due to force from below lifting the deck on which personnel are standing. These are characteristic of torpedo and submarine mine explosions. Blast injuries occur due to proximity to explosions, particularly among personnel in the water not sufficiently distant from the shock waves of exploding bombs, depth charges and torpedoes.

The organization and training for handling casualties aboard ship follow certain principles although details vary according to the type of ship. These principles are: (1) Training of *all* personnel in the fundamentals of first aid so that it may be given to the wounded man by whoever is nearest and free to do so. (2) Distribution throughout the ship of teams of

TABLE II
CASUALTIES DUE TO ENEMY ACTION, U. S. MARINE CORPS, DECEMBER 7, 1941 TO DECEMBER 31, 1946*

Method of Disposition	Marine Corps		
	Total	Officer	Enlisted
Total	74,219	3,824	70,395
Killed in action	17,099	1,192	15,907
Died prisoner of war	513	62	451
Wounded:			
Died subsequently	1,629	87	1,542
To duty	44,551	2,405	42,146
Invalided from service	9,968	41	9,927
Deserted	34	1	33
Disposition undetermined†	425	36	389

* Source: "K" file card, "Individual Statistical Report of Patient"; data are provisional as of July 1, 1947, date of compilation.

† Includes patients remaining on the sick list (319 as of July 1, 1947), and those whose records are lost or otherwise unavailable; no deaths are included in this total.

hospital corpsmen and stretcher bearers who may go to the scene of the casualty with the material repair party, collect the wounded, give further first aid and transport them to a protected area or collecting station. (3) Life saving measures by the medical officers, such as treatment of shock and arrest of hemorrhage, splinting of fractures, dressing of wounds and emergency major surgery. (4) Transfer from the combatant ship to a hospital ship or shore hospital at the earliest possible opportunity. This transfer may be by small boat but in the recent war intership transfer at sea with both ships under way was highly developed.

The general principle in caring for casualties is to save life, prepare casualties for transfer and get them clear of the ship at once in order that the ship may be ready for further action if necessary. The wounded arrive eventually at a base hospital somewhere in the zone of communication.

MARINE CORPS CASUALTIES

The amphibious operation of bringing an offensive force to an enemy stronghold, landing

it on a strongly held beach against opposition and supporting it until it has secured a firm foothold is an operation requiring the utmost cooperation of sea, air and ground forces. The Marine Corps which is a part of the Navy were the pioneers in amphibious warfare and their stretcher bearers where a beach medical officer continues their care, sorts them and directs their transfer by boat to appropriate ships. As the assault line moves inward from the beach more medical components come ashore from the transports, battalion aid sta-

TABLE III

WORLD WAR II CASUALTIES DUE TO ENEMY ACTION U.S. MARINE CORPS; SELECTED ENGAGEMENTS DECEMBER 7, 1941 TO DECEMBER 31, 1946

Place of Action	No. of Marines Engaged	Casualties Due to Enemy Action					
		Total		Killed		Wounded	
		No.	Per Cent	No.	Per Cent	No.	Per Cent
Guadalcanal-Tulagi landings	32,650	3,900	11.9	1,078	3.3	2,822	8.6
Battle of Tarawa	17,000	3,074	18.1	988	5.8	2,086	12.3
Battle of Cape Gloucester	17,000	1,446	8.5	358	2.1	1,088	6.4
Invasion of Marshall Island	15,600	1,638	10.5	434	2.8	1,204	7.7
Invasion of Mariannas Islands	127,800	17,163	13.4	4,335	3.4	12,828	10.0
Invasion of Palau Islands	24,800	6,388	25.6	1,273	5.1	5,115	20.6
Battle of Iwo Jima	61,000	19,001	31.1	5,523	9.1	13,478	22.0
Bombardment and landings on Okinawa	72,800	14,749	20.3	3,242	4.5	11,507	15.8

several major operations in this field resulted in thousands of casualties during the recent war. (Table III.) As the medical component of the Marine Corps consists of Naval medical personnel the care of these casualties was and is the responsibility of the Naval Medical Department.

As long as the Marine is aboard ship, either for duty or enroute to an assault, he is subject to the same hazards as previously described. The medical officer of the ship cares for him if he is wounded and the ship's organization is responsible for his disposition. As soon as he lands on the beach the medical organization of his company, battalion or regiment cares for him if wounded. The nature of the wounds sustained in these operations are no different than in other military operations. There are the ragged wounds due to exploding shells and bombs, the wounds due to rifle and machine gun wounds and bayonet wounds incurred in close combat.

The wounded of the first assault waves are given first aid by the hospital corpsmen and medical officers attached to their companies or battalions. They are carried to the beach by tions are established and soon a medical battalion may erect a field hospital in which major surgery is carried on within a relatively short distance from the front lines. Specialized equipment which may be quickly transported to the beach and put in use rapidly has been developed, e.g., mobile surgical trailer. Surgical teams which have been working aboard ship come ashore early and continue their work in the mobile operating rooms.

In 1942, at our first amphibious assaults, wounded were returned by boat (the same boats that brought the assault troops ashore) to the transports. Here they were treated by the ship's medical officer until the ship returned to base where they were transferred to a base hospital. Sorting of wounded on the beach was under difficulties, and boat transport was uncertain as the craft might be required for other more important missions.

As the war progressed the technics of transferring the wounded improved as hospital ships became available and special craft for sorting and transporting casualties were developed. In a large assault several hospital ships were made available. Special amphibious craft

were equipped for transporting the wounded. These picked up the wounded either at the battalion aid station or on the beach and carried them to an LST which was especially equipped for sorting and classifying the wounded. From these ships they were sent by hospital boats to the hospital ship lying offshore. When a hospital ship was filled, it departed for a base hospital and its place was taken by another. These hospital ships were fully equipped floating hospitals with medical staff, nurses, equipment, etc., as good as any modern hospital.

Later in the campaign, when enough territory had been secured and an airfield captured or built, air evacuation of the wounded was utilized. This method of transfer of casualties proved its efficacy early in the war. As planes and personnel became available air transport assumed increasing importance. In the Marianas campaign in 1944 less than 10 per cent of the casualties were evacuated by air. In 1945, in the Okinawa campaign, 50 per cent of the casualties were evacuated by air.

HOSPITALIZATION IN REAR AREAS

The wounded man arrives at a base hospital in a rear area in the zone of communication whether his injury was sustained aboard ship, in aerial flight or on shore in an amphibious assault. He may have reached the base hospital by ship or plane. These base hospitals are fully equipped and staffed. The capacity may vary from 200 to 1,500 patients. Here the patient is fully evaluated, definitive treatment begun and the patient brought to the optimum condition for further transfer to the United States if this step is necessary.

If the patient's period of expected disability is relatively short he may be kept at a base hospital until fully recovered and then return to his ship or organization. He may be transferred from one hospital to another in the zone of communication for several reasons, such as to distribute the patient load, to be in a more salubrious climate or to receive specialized treatment in a hospital designated for treatment of special cases, such as head injuries, thoracic wounds, compound fractures, etc.

In the base hospitals a policy must be formulated to serve as a guide in determining which patients shall be transferred to the United States for treatment. Certain casualties such as the amputees, the blind, those with severe injuries of the nervous system, femur fractures, etc., must obviously be transferred to the United States. In the South Pacific area in 1942 to 1943 the policy was that any patient in a base hospital who was expected to require ninety days or more of treatment would return to the United States. This time limit is variable and may depend on the following factors. (1) Need for hospital beds; (2) distance to the United States; (3) speed and availability of transport to United States and (4) climate of the rear area (tropical or subtropical). In any event it is probable that an average of 75 per cent of the casualties reaching a base hospital in the zone of communication (rear area) will require transfer to the United States for completion of treatment. This transfer may be by ship or plane. In World War II it was at first almost exclusively by ship. Later, as planes became available, air transport of stretcher casualties to the United States was the rule. If transferred by ship, they receive care enroute from the medical staff of the ship—usually only such care as is necessary to carry out the type of treatment already instituted. If transferred by plane, nursing care by the flight nurse and corspmen is all that is necessary during the short period on board the plane.

DISTRIBUTION OF CASUALTIES WITHIN THE UNITED STATES

Casualties arrived in the United States at the Port of Embarkation and were transferred from plane or ship to the hospitals at that particular port. In the early days of the war the hospitals at our Pacific ports of embarkation were under considerable strain to handle the incoming patients. Our concept of the necessity of screening had not been fully developed and the large hospitals which were built at these ports found themselves in the position of receiving large groups of patients for screening and at the same time attempting to carry out definitive care for the patients already in the hospital. Later receiving hospitals were established at the Port of Embarkation which received all patients returning to the United States whether by ship or plane. At these receiving hospitals patients were screened and given necessary care, allowed to recover from the effects of their trip if it had been prolonged and then transferred on to other hospitals throughout the country. This transfer took

place by ambulance to hospitals within the immediate vicinity, by train for large groups of patients going a distance and by plane for small groups of patients or for those requiring rapid transfer to a special hospital. Later as more planes became available more of the transfers were accomplished by air transportation. The distribution of these patients was controlled from a central source and their destination was usually dependent upon several factors. (Table IV.)

TABLE IV

TRANSFERS OF NAVY AND MARINE CORPS HOSPITAL PATIENTS AUTHORIZED BY THE BUREAU OF MEDICINE AND SURGERY 1944 TO 1947*

Period of Time	No. of Patients	Type of Transfer
October to December, 1944	11,022	All transfers
1945	97,592	Transfers of overseas casualties and transfers for special-type treatments
1946	10,707	Transfers of overseas casualties; transfers for special-type treatments
1947	2,170	Transfers for special-type treatments

*Source: Professional Division, Hospitalization Branch; all data are approximate; data include only those transfers authorized by the Bureau of Medicine and Surgery. Transfers between hospitals within a Naval district are authorized by the commandant of the district and are not included in these data; with the decrease in doctors, the number of transfers of patients for special-type treatments increased.

The first factor was the type of injury, for example, the Navy maintained amputation centers at the Naval Hospital at Mare Island and the Naval Hospital, Philadelphia. The center for the treatment of the blind was at the Naval Hospital, Philadelphia. Several hospitals were designated for plastic surgery and for surgery of the nervous system. The second factor was the man's home. If the proper type of hospital with vacant beds was located in the general vicinity of the patient's home, he was transferred to it. At these hospitals the patient's final definitive care was carried out and he either recovered and returned to a duty status or he was discharged from the service when hospital care was no longer needed. (Table V.)

Near several of our larger hospitals which carried heavy loads of casualties convalescent hospitals were established. These were available for the reception of ambulatory patients in the convalescent stage who required some rehabilitation and time before returning to service. Theoretically this was an ideal arrangement but practically it did not work out too well for wounded patients. Pressure of incoming patients frequently resulted in patients being transferred to a convalescent hospital before they were ready for it. At best it resulted in the casualty being passed along into the care of another individual surgeon at perhaps the most critical period of his treatment.

TABLE V

AREA OF RESIDENCE OF NAVAL PERSONNEL AND AREA DISTRIBUTION OF PATIENTS IN NAVAL HOSPITALS

	Residence of Naval Personnel (per cent)	Location of Patients in Hospitals (per cent)
Pacific states	10.9	47.1
Mountain states	3.4	3.7
Midwest, west of Mississippi	12.9	4.0
Midwest, east of Mississippi	25.8	6.2
Atlantic states	33.1	33.9
New England states	7.9	5.1

Continued movement of the wounded man in wartime from the place of wounding to the hospital where he completes his treatment constitutes a major difference between wartime and peacetime care of casualties. It is almost as if the wounded man were on the belt of an assembly line moving away from the forward area with various individual medical officers and hospitals giving him treatment as he moves along toward his recovery or ultimate disposition. At any point as the belt moves along he may recover sufficiently to be taken off the line and be returned to his station or he may stay on the belt until he reaches the end which may be return to duty or discharge from the naval service. In general, it may be said that the farther along the assembly line the patient moves, the less chance there is that he will return to duty in the service. (Table VI.)

This organization for the treatment of casualties imposes on the service and its medical officers certain duties and obligations not always present in peacetime or civilian care of casualties. The first obligation is for some uniformity or standardization of method of treatment of each type of trauma. These standard methods must be established early

and all medical officers indoctrinated in them. Obviously if a man with a compound comminuted fracture of a major bone is to be treated by several surgeons successively, some unanimity of thinking is required for his treatment if proper results are to be obtained. If

TABLE VI

	Flow of Casualties	
Theater of Operations	↓	Combat ships; amphibious assault troops; bases (front line); sea areas in dispute with enemy; enemy country (not secured)
Zone of Communication	↓	Overseas bases; island possessions; advanced bases
Zone of Interior	↓	Continental United States

the first surgeon uses reduction and fixation by the Stader apparatus, the second disagrees and substitutes a Roger Anderson fixation, the third believes plaster alone is sufficient and the fourth perhaps favors traction, the patient recovers good function *in spite of* rather than because of his treatment.

Basic standard procedures for general use must be determined for each particular type of trauma. These basic standard procedures must permit flexibility of application and adaptation to variants of each type of trauma. There must be training in these basic procedures and training for flexibility of application. Once determined and established these standard procedures must be widely promulgated and all must abide by them. I venture that in the event of another war the same tenets will hold regarding the treatment of the hundreds of thousands of civilian casualties we may expect. War is not the time for individual surgeons to ride their own hobbies or perfect their own methods if they are at variance with the standard treatment. It is along these lines that the American Association for the Surgery of Trauma can do yeoman work in determining the basic standard procedures and indoctrinating the surgical profession in their technics.

Another duty imposed on all who treat this wounded man on the moving belt is the keeping of careful records. Not only the keeping of accurate, detailed records but the forwarding of these records with the patient to the next hospital when he is transferred. In peacetime or in civilian life case records are kept for several reasons, such as hospital files, for study and evaluation of methods of treatment, statistical purposes, legal uses, etc. Case records of war casualties may be used for any of these purposes but their primary object is to pass on to each succeeding medical officer a complete, succinct record of all that has gone before in the history, progress and treatment of each casualty. These records together with x-ray films and other pertinent laboratory data should always go with the patient. Copies may be placed in hospital files but complete records must go with the patient to ensure continuity of treatment at all times.

LESSONS FROM WORLD WAR II

Every war in which this country has been engaged has had its own pattern. In planning our measures for care of naval casualties in the event of another war we must not fall into the error of basing all our plans on the pattern of the last war. However, certain concepts were developed which we may expect to be useful in any future war.

First, rapid evacuation of casualties by air transport to modern, highly equipped base hospitals with well trained staffs within easy reach of the forward areas. Second, utilization of air transport to move casualties from base hospitals to the United States thus avoiding the days and weeks of a sea voyage when treatment tends to be static rather than advancing. Third, establishment at Ports of Debarkation in the United States of receiving hospitals whose only function is the reception of overseas casualties screening and early transfer to appropriate hospitals. Fourth, establishment throughout the country of hospitals devoted to specialized treatment of various types of trauma, such as plastic surgery, amputations, peripheral neurosurgery and the blind and the deaf.

In summary, it may be said that the organization within the Navy for the care of casualties in war calls for team work and cooperation of the highest order. Basic standard procedures or uniform methods of treatment must be developed and adhered to by all hands participating in the immediate care of the patient. The rôle of this Association in developing these methods and inculcating the medical profession with proper technics can be of immeasurable assistance in preparing to resist future aggression.

TRANSITION IN BURN TREATMENT

THE WAR YEARS

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DURING the past thirty years which have encompassed two world wars treatment of burns has undergone considerable metamorphosis. Since this interval coincides with the time during which the author has been actively interested in burn treatment, it provides a convenient period for cursory review preliminary to mapping present trends.

At the beginning of World War I the common methods of burn treatment were applications of carron oil or various ointments, open air drying under a cradle and warm tub baths. During that war the ambrine or paraffin spray method of local treatment became popular. It was in fairly general use until the beginning of the coagulation regimen (1925), and it was adhered to by some throughout the latter era. Introduction of the Carrel-Dakin method of treating infected wounds at about the same time as ambrine came into use also greatly influenced subsequent burn treatment.

Beginning with the publication by Davidson of observations on the coagulation of burns with tannic acid, a trend was instituted which dominated burn literature in all languages until the early years of World War II. In the meantime brief flurries of interest have been recorded in cod liver oil, "shot-gun" ointments of various sorts, various preparations containing sulfa drugs and the application of inert films to the burned surface.

Prior to the entrance of the United States into World War II British observers had objected to the use of coagulating agents upon burns of the hands or face on the grounds that these substances destroyed epidermis not damaged by the burn. Then followed, chiefly by the British, the advocacy of warm saline baths and the Bunyan envelope.[12] In the meantime Allen and Koch[3] had reported in the American literature the use of fine mesh dry or petrolatum gauze in the local treatment of burns. Following the trend in the British literature, a number of observers began to question not only the local destructive effect of tannic acid on epidermis but brought forth clinical and experimental evidence to indicate that tannic acid produced liver necrosis.[5,8,10,25,30,44] The observations of the Boston group on the victims of the Cocoanut Grove fire produced further doubt concerning the virtue of the coagulation regimen.[20]

The death knell of the regimen was sounded by McClure before the American Surgical Association in 1944,[34] by an editorial in the *Journal of the American Medical Association*[23] and by the Surgeon General of the United States Army whose circular letter in September, 1944 and TB Med. No. 15, March, 1945 prohibited the use of the coagulation regimen by the Medical Corps of the Army and made the vaseline pressure dressing the official method of burn treatment. The action of the Surgeon General was predicated upon the recommendations of the National Research Council and the Committee on Medical Research.[31]

Review of the published observations which led to the condemnation of the coagulation regimen leaves one in some doubt concerning the relative significance of liver changes produced by tannic acid in animals and those which had been known for years to occur in the liver of the severely burned patient.[6] Some of the observations could have been more adequately controlled. Be that as it may, the coagulation regimen has been buried by the weight of professional opinion. It has been superceded by what is usually called the vaseline pressure dressing, a method which is in most respects comparable to the ambrine dressings used in World War I.

THEORETICAL CONSIDERATIONS

From the time of early observers it has been assumed that a toxic substance was produced at the site of the burn and that this was the lethal factor.[6,45] This theory has never been proven nor disproven. It was to fix this theoretical toxin that Davidson instituted the tannic acid regimen. Some evidence has been produced that this unknown substance may be a product of the protein breakdown at the site

of the burn. Some evidence suggests that it may be an enzyme.[7,47] Underhill[43] and his associates explained all the lethal effects of the burn by anhydremia. More recent experimental work[15,24] makes it clear that rapid fluid shift plays an important part in producing the systemic effects of burning and that this process can be limited to some extent by a pressure dressing.[14,16] Aldrich[2] attempted to explain the lethal effects of burns as due to the products of bacterial growth at the site of the burn. While there can be little doubt that infection plays a significant rôle in some of the late deaths, there is little evidence to support it as an early cause of death.

While most of the physiologic effects of burning can be explained upon a physiochemical basis, most experienced observers believe that there is an unknown factor which occasionally causes death which cannot be adequately explained on the basis of known phenomena. Bosse, Gross and Hagan[9] called attention to the unreliability of hemoconcentration and hypoprotinemia as a prognostic indication in certain burned animals. This fact has been confirmed by the author.

Control of Shock and Fluid Balance. The importance of fluid replacement in shock associated with severe burns has long been recognized. The work of Underhill and that of Coller and his associates focused attention upon this factor. The tendency during the twenties was to use large amounts of electrolyte fluid alone to combat shock and maintain fluid balance. It was found, however, that fluid given parenterally in excess during the early days of the burn led to generalized edema. With recognition of the fact that the protein content of the blister fluid as well as that accumulated in the subcutaneous tissue at the site of the burn caused depletion of protein reserves, the value of replacement with protein-containing fluid was established.

At the beginning of World War II large amounts of human plasma were recommended during the "shock phase" of the burn. This seemed logical and was found to be a better method of combatting shock than electrolyte fluid alone. Patients still continued to show edema, however, and in some shock was not overcome by the plasma. While before this time Riehl,[39] Scudder[40] and Harkins[29] had recommended the use of whole blood during the early stage of burn treatment, the general belief was that to add red cells to the circulation was to increase the concentration that already existed.

It was customary to see oliguria during the second to fourth day of the severe burn, during which interval the urine contained protein, hemoglobin, casts and sometimes red cells. Then around the tenth day the output would often exceed the intake. This renal depression was thought to be due to the burn toxin. The work of Bywaters,[13] Olsen and Necheles,[33] Mallory and others, showing that the convoluted tubules are blocked due to severe shock, probably explains the phenomena better. Shen and Ham[41] showed both *in vitro* and *in vivo* that exposure to high temperatures even for short intervals produced fragmentation and increased fragility of the circulating red cells. This explains even more fully the blockade of the renal tubules and the finding of hemoglobinuria and hematuria. Their work also explains the common finding of secondary anemia when the shock phase of the burn is over, an anemia which we were formerly inclined to attribute to the result of absorption of bacterial products from the surface of the burn. Moore, Peacock, Blakely and Cope[35] showed convincingly that the "false" anemia of the second degree burn was due to dilution while the true anemia of the third degree burn was due in the earliest stage of the burn to hemolysis, later due to injury of the red cells and depression of bone marrow and still later due to infection about and hemorrhage from the granulating wound. McDonald, Cadman and Scudder[35] also showed that in second degree burns the plasma loss is greater while in third degree burns the red cell mass is depleted.

The rationale of the present trend to combat burn shock with whole blood plus electrolyte solution limiting the administration of plasma becomes apparent. Practical experience during the last war impressed the necessity of whole blood rather than plasma for the control of severe shock, regardless of its cause. The danger of producing homologous serum hepatitis from pooled plasma is a further deterrent to its use in large quantities. Recent experience would seem to indicate that the use of whole blood during the stage of shock and anhydremia when accompanied by an appropriate volume of electrolyte solution does not increase hemoconcentration. Much helpful experimental and clinical work has been reported by Abbott and

associates,[1] Cameron,[15] Coller and his associates,[18] Cope, Moore and their associates,[21,36,37] Elman,[24] Evans and Bigger,[26] Harkins,[29] McDonald, Cadman and Scudder[35] and Olsen and Necheles.[38] The weight of evidence seems to favor a judicious combination of whole blood, electrolyte solution and plasma, with somewhat less emphasis on the latter than before the war. In general, the massive shift of plasma which accompanies the extensive second degree burn produces hemoconcentration which is best met with large amounts of electrolyte solution and plasma. Deep burns produce more severe immediate shock and loss of red cell mass, and here the demand is for large amounts of whole blood and electrolyte and less plasma. Efforts to follow formulae for the administration of the various fluids have led to considerable confusion. Before the War the tendency was to use replacement formulae based upon the hematacrit reading. The Conference on Burns of the National Research Council in 1942 recommended using a surface area formula instead of the hematacrit reading, and at this time Harkins recommended a liter of plasma and an equal amount of salt solution for each 10 per cent of the body surface involved. Cope and Moore[21] used a surface area formula calling for 75 cc. of plasma and 75 cc. of non-colloid-containing electrolyte solution for each 1 per cent of the body surface burned. They developed other formulae on the basis of interstitial space expansion but emphasized the need for careful checking therapy with continuous observations on renal output. Other observers believe that following such formulae will tend to overtreat the patient and may place a dangerous burden upon the circulation and that more emphasis should be placed upon whole blood administration. While there has been at times advocacy of administering massive amounts of fluid during the stage of oliguria or anuria due to renal blockade, the present trend is more conservative.[18] In the light of present knowledge it seems wise to guide fluid therapy on the basis of careful blood observations, renal output and clinical acumen.

Control of Infection and Protein Depletion during the Later Phase of Burn Treatment. It seems proper to separate late treatment of burns from early treatment. Failure to do so has led to considerable confusion in the literature. For the first few days following the burn treatment is directed toward life saving measures, treatment of shock, maintenance of fluid balance and blood volume, replacement of damaged red cells and plasma protein and avoidance of contamination and tissue edema at the site of the burn. Later the problem consists of management of a necrotic wound that is potentially or actively infected while maintaining the patient in a good nutritional state. Superficial burns pose no problem since they are healed within two or three weeks irrespective of the type of dressing employed, provided gross contamination is not permitted. But when the deep layers of the skin are partially or completely destroyed over a large area of body surface, the possibilities of infection, tissue protein depletion and anemia are great. It is often erroneously assumed that a wound produced by burning is free from infection because it was carefully cleansed at the time of initial treatment and the integrity of the original dressing has been undisturbed since that time and because the patient has been receiving antibiotics, sulfa drugs or both. Too much emphasis has been placed upon the dictum that the initial burn dressing should be left in place for a given number of days. Some surgeons have misinterpreted this dictum to the serious detriment of the patient by leaving in place for days a dressing which was obviously enclosing an infected wound. As a case in point, we recall the case of a young soldier who was transferred to our overseas general hospital desperately ill from a severe burn. He had become toxic on the fifth day and ran a temperature elevation of from 41 to 41.5°C. for several days, during which time he was comatose. His initial dressing had been left in place because "instructions were to leave the first dressing on for ten days." During the interval of marked hyperpyrexia he developed an aphasia and paresis of the right arm which persisted long after the burns were entirely healed.

Significant temperature elevation after the third or fourth day almost always means infection at the site of the burn and appropriate treatment is to be instituted promptly. Just what constitutes appropriate treatment finds very little agreement among authors in the literature. Some of the recommended measures are: (1) to continue vaseline pressure dressings, giving penicillin parenterally; (2) penicillin locally; (3) saline compresses; (4) tub baths; (5) surgical débridement followed by skin graft;

(6) continuous Dakin's solution until ready to graft skin and (7) pyruvic acid. It is important that a method be used which will get rid of slough and minimize bacterial flora in the shortest possible time in order that spontaneous healing or skin grafting may be completed promptly before the patient's healing powers are impaired by protein depletion or anemia.

TABLE I
EFFECT OF WOUND TREATMENT UPON BACTERIAL COLONY COUNTS

Days of Treatment	Method of Treatment	Colony Counts on Wound Washings	Appearance of Wound
3	Dry dressings	Innumerable	Little slough
3	Dakin's solution	40	Clean
2	Physiologic saline	Innumerable	More exudate
1	Dakin's solution	50	Clean
3	Dry dressings	Innumerable	More exudate
1	Petrolatum gauze	Innumerable	Thicker exudate
2	Dakin's solution	150	Clean
6	Sulfa and petrolatum	2,000	Much exudate
3	Dakin's solution	100	Clean

Penicillin or sulfa drugs are relatively ineffectual either locally or systemically in the presence of slough or exudate as shown by bacteriologic studies. (Tables I and II.) Table I shows the range of variation in bacterial colony counts on wound washings from a large granulating wound. In each instance 0.1 cc. of the 30 cc. of physiologic salt solution used to flush the granulating surface was plated with 5 cc. of blood agar. The column at the left indicates successive days of treatment. "Innumerable" indicates that colonies were too numerous to count. Colony counts were also checked with direct bacterial counts on smears. These generally ran parallel to the colony counts except when petrolatum gauze in contact with the wound stimulated so much cellular exudate that the direct smears were useless. The observations recorded in this table and in Table II are typical of many made in the course of wound studies. Tub baths are somewhat more effective but are not always well tolerated by severely burned patients. Pyruvic acid as advocated by Connor and Harvey[19] is difficult to prepare, painful to apply and impractical for large surfaces although it dissolves slough rapidly. Surgical débridement, as recommended by Allen,[4] is an attractive method and in his hands has been very effective. He examines the wound under anesthesia on about the tenth day, excises the necrotic slough and applies a sterile, fine mesh gauze dressing; he then applies a skin graft two or three days later. The chief limitations of the method are those of size. Very large areas cannot be treated in this manner even with large quantities of available blood. Dakin's solution dressings provide the most generally useful and safe method of treating the large burned surface at this stage. Both experimental and clinical evidence have shown that it dissolves slough rapidly and at the same time reduces bacterial flora of the pathogens to a minimum level. With effective hypochlorite dressings, it is usually possible to get rid of slough and cleanse a wound adequately for skin grafting in from three to ten days. An occasional case with deep slough will require more time.

TABLE II
EFFECT OF WOUND TREATMENT UPON BACTERIAL COLONY COUNTS

Days of Treatment	Method of Treatment	Colony Counts on Wound Washings	Appearance of Wound
3	Dakin's solution	600	Clean
3	Penicillin locally*	1,800	No change
3	Penicillin locally and intramuscularly	10,000	More exudate
3	Dakin's solution	250	Clean
3	Dakin's solution	10	Clean
2	Physiologic saline	Innumerable	More exudate
3	Azochloramid†	Innumerable	More exudate
3	Dakin's solution	200	Clean

* The penicillin solution used contained 20 units per cc.

† The difference in effect of azochloramid and Dakin's solution is explained by the rapid release of available chlorine by the latter and by the stability of the former. Experimental observations indicate that when in contact with human blood plasma *in vitro* Dakin's solution loses 77 per cent of its available chlorine in one hour while azochloramid loses none. Similarly, when Dakin's solution is dripped slowly (3 drops per minute) through a subcutaneous wound, it loses 89 per cent of its available chlorine while azochloramid loses 5 per cent. With rapid flow through the wound (60 drops per minute), Dakin's solution loses 21 per cent while azochloramid loses none.

IMMEDIATE SKIN GRAFT OF FRESH BURNS

For years circumscribed, small, deep burns have been excised and skin grafted immediately with good results. Several observers, notably Young[46] and Cope,[22] have recently advocated the immediate excision and skin grafting of full-thickness burns. The idea is attractive but impractical. In an occasional instance a full-thickness area of burn of moderate size can be excised and grafted immediately with time-saving and safety to the patient. Observers agree, however, that it is virtually impossible for even the most experienced surgeon to determine accurately at the outset the extent and depth of the burn. The immediate graft must then be done on the basis of a guess which may err either on the side of wasting good skin or not excising enough. It is also quite apparent that for the desperately ill patient already in severe shock the method is quite impractical.

STATISTICAL DATA

Statistical data on the treatment of burns are meager and difficult to evaluate. In other publications we have summarized figures that were available in the literature.[28] In Table III we have brought our own continuous series of burns up to date. This series started with the ambrine era and ends with the pressure dressing era. The only valid deduction seems to be that during the coagulation regimen the mortality from burns treated under otherwise comparable conditions improved. No significant change in the mortality can be attributed to the pressure dressing regimen.

ARMY EXPERIENCE

It was hoped that observations made during the recent war would provide material which would be helpful in evaluating burn treatment. This is, unfortunately, not the case. Burn treatment was not standardized in the armed forces until after TB Med. No. 15 made the pressure dressing technic mandatory in the Army, and the available records suggest that no valid conclusions concerning the effect of treatment upon mortality can be reached. Gross mortality figures for burns from the Army for the years 1943 and 1944, computed from samples of significant size,[11] are summarized in Table IV. These figures give an overall mortality from burns of 6.8 per cent for these years and a mortality of 5.2 per cent for non-combat burns. While the latter figure is superficially comparable to figures from civilian hospitals, it is weighted on one side by the high mortality from aircraft burns and on the other side by the fact that the figures also include many burns that were not serious enough to require hospitalization. From a sample of 1,532 burns reported by Army hospitals in the Southwest Pacific area, summarized by the author, gross mortality was 2.08 per cent. It is estimated that not more than one-half of these burns were treated by the pressure method.

TABLE III*
BURN MORTALITY

Treatment	No. Patients	Deaths	Mortality, (Per Cent)
Ambrine, etc.	121	17	14.0
Coagulation	1153	86	6.1
Pressure Dressings	231	14	6.0
Totals	1505	117	7.7

* Continuous series of burns on author's service, St. Luke's Hospital.

The army experience brings out the following observations, on the basis of published and personal communications, mostly from the Pacific theater. Several variations in treatment were advocated by individual surgeons. Some preferred plaster to a soft dressing, particularly for patients requiring long evacuation routes. Various applications to the burned surface and methods of cleansing were advocated, there being little unanimity concerning details. The general trend favored simple cleansing under aseptic conditions and a bland type of local dressing. The average comment of surgeons in official reports favored the pressure dressing method. Many, however, had encountered a high incidence of infection among patients so treated by forward units. Some were outspoken in stating that the incidence of infection was definitely higher than among patients treated primarily by tannic acid and silver nitrate, irrespective of the use of sulfa drugs or penicillin. Several reported that patients requiring long transportation in the tropics arrived in poor condition with dressings saturated with foul discharge. Some observers

thought infection was due to inadequate cleansing and asepsis at the time of initial treatment while some believed that the difficulty was inherent in the method of treatment. Some other unfortunate sequelae were recorded which were attributable to misapplication of the pressure principle. Several instances of radial or common peroneal palsies and one instance of a Volkmann's contracture were reported from pressure dressings that were too tight. It may be stated that the author has observed similar complications in civilian hospitals.

TABLE IV*
BURN MORTALITY

	1943			1944		
	No. Cases	Deaths	Mortality, (per cent)	No. Cases	Deaths	Mortality, (per cent)
Combat	751	220	29.3	2,400	816	34.0
Non-combat	24,858	950	3.8	35,713	2,416	6.8
Non-aircraft	24,374	283	1.1	34,799	578	1.6
Aircraft	1,325	887	71.8	3,314	2,654	80.0
Non-combat aircraft	1,032	753	73.0	2,674	2,160	80.8
Total cases	25,609	1,170	4.6	38,113	3,232	8.5
Overall mortality for these years						6.8%
Overall non-combat mortality						5.2%

* United States Army figures published in the Bull. U. S. Army M. Dept.[11]

Comment. The interval of time spanning two world wars has witnessed considerable change in the local treatment of burns and marked progress in understanding of the systemic effects produced by severe cutaneous burns. It has witnessed the birth and death of a radical departure in local treatment, with return to the general principle of management in vogue at the beginning of the period. It has also witnessed an appreciable overall lowering of mortality from burns. The reduction in mortality occurred during the era when the coagulation regimen was in vogue and has not thus far been significantly altered by the general adoption of the pressure dressing principle. It would seem, therefore, that local treatment of the burn may have been of less importance than interest which the coagulation regimen stimulated in the burn problem and the benefits which accrued from more systematic treatment. Better treatment of shock, maintenance of fluid balance and control of infection are probably factors also. It must be recalled, however, that the major reduction in burn mortality took place before penicillin was discovered and sulfa therapy was in its infancy. No figures are available which give any indication concerning the effect of the widespread use of penicillin. It is not to be expected, however, that control of infection will greatly alter mortality figures since the majority of deaths occur during the first seventy-two hours at a time when infection can rarely be considered a lethal factor.

On the basis of present day knowledge the objectives of burn treatment are: (1) To treat shock and hemoconcentration. (2) To cleanse the wound simply and gently and keep it as free as possible from contamination by means of a dressing which also limits fluid loss from the injured surface, limits deposition of edema fluid in the subcutaneous tissues and helps to immobilize the injured part. (3) To maintain fluid balance by introducing water, electrolyte, blood or protein-containing fluid sufficient to meet calculated losses and provide for an adequate urine output. (4) To combat infection at the site of the burn by both local and systemic measures whenever its presence is apparent. (5) To create both local and systemic conditions which will favor the earliest possible closure of the wound with skin of good quality.

There were obvious advantages of local treatment of the burned surface by coagulation, mainly, it was relatively easy to maintain a

clean, dry field for several days after treatment and local fluid loss and edema were minimized by the pressure of the coagulum. A harmless method of coagulating the surface of the burn would still be desirable. Experimental use of inert and impregnated films has thus far been inconclusive. The work of Chase[17] who produced a coagulum with extract of beef aorta offers possibilities but has not yet been used extensively.

Vaseline gauze or other petrolatum base ointments have undesirable features when in contact with necrotic tissue or a granulating wound. It has been shown by the author and others that petrolatum increases wound exudation, which exudate in turn considerably decreases the effectiveness of either sulfa drugs or penicillin. The ideal local treatment for the burned surface is yet to be found.

DETAILS OF MANAGEMENT

Shock Treatment—Fluid Balance. An immediate evaluation of the patient should include the following considerations: (1) extent of the burn, (2) depth of the burn, (3) presence of shock, (4) presence of hemoconcentration.

The presence or absence of hemoconcentration can be determined immediately with reasonable accuracy by means of the copper sulfate estimation of blood specific gravity and conversion to an hematacrit value. This procedure requires but a minute or two and checks well enough with other methods to be practical for making serial observations during the critical stage of the burn. Subsequently, a red cell count, hemoglobin and hematacrit estimations, plasma chlorides, total protein, and nonprotein nitrogen determinations are made: these are repeated as found expedient. Even in the absence of the latter tests, however, the copper sulfate specific gravity estimations and careful clinical observation are adequate guides to therapy.

After the brief preliminary survey of the patient a well coordinated plan of treatment is followed out. It is essential that the plan be simple and that it be carried out without delay and without interruption.

The immediate possibilities for consideration are as follows:

1. If the burn is of moderate extent and depth and the patient shows no evidence of shock or hemoconcentration, local treatment of the burn is carried out at once without intravenous therapy, depending upon oral administration of fluid.

2. If the burn involves a large surface area but mostly of second degree depth and especially if there is already evidence of hemoconcentration, intravenous administration of plasma is begun at once. Plasma, 500 cc. to 1,000 cc., are given within the first six hours and an equal amount of Ringer's solution or physiologic salt solution is also given preferably simultaneously. If hemoconcentration increases in spite of therapy, the same quantity of plasma and electrolyte solution is administered later in the day. The patient is encouraged to take as much fluid by mouth as is tolerated. If the patient begins to vomit during the first twenty-four hours, at least an additional liter of electrolyte solution is given intravenously. Early vomiting is an unfavorable prognostic sign. The total fluid intake for the first day will be between 3 and 4 L. for the average adult of about 55 Kg. The intake for children will be in proportion to weight plus about 25 per cent. The patient is encouraged to take milk or other protein-containing fluid by mouth if tolerated. If later on the first day the patient shows evidence of shock, whole blood is to be substituted for the recommended dosage of plasma.

3. If the burn involves a moderate to large surface area (30 to 60 per cent) a considerable portion of which is presumed to be third degree and especially if the patient is admitted in shock, plasma is started intravenously at once and given rapidly. As soon as cross matching has been completed whole blood is substituted for the plasma and is covered by an equal amount of electrolyte solution. Thus, within the first six to eight hours, the average adult patient will receive approximately 500 cc. of plasma, 1,000 cc. of whole blood and 1,500 cc. of electrolyte solution. If the shock state continues, the blood and electrolyte solution is repeated. Fluids are given by mouth as tolerated. If hemoconcentration supervenes, plasma and electrolyte solution are substituted for whole blood. If the patient continues at shock level at the end of twenty-four hours, similar intravenous therapy is continued, but the prognosis may be regarded as very poor.

4. If the burn is of relatively small size (less than 3,200 sq. cm.) and obviously of full-thickness depth and the patient shows only minimal to moderate shock, plasma and blood

may be administered and the patient prepared for immediate excision and skin graft. At least 3,000 cc. of compatible blood must be available before starting the procedure.

On the second day the intravenous fluid will consist of whole blood and electrolyte solution unless hemoconcentration indicates that plasma should be substituted. The intake should equal or moderately exceed that of the first day. On this and subsequent days the urine output is carefully observed and recorded. The output is likely to decrease on the second and third day and proteinuria and hemoglobinuria may be observed.

If on the third or subsequent day renal suppression appears to approach anuria, it may be helpful to record the hourly urine output with an indwelling catheter in place as suggested by Cope et al.[21] If the hourly output falls below 20 cc. for several hours and is not considerably increased by intravenous administration of 1 L. of 5 per cent dextrose solution, it may be assumed that renal blockade is impending. To attempt to force out the renal blockade at this stage by administering large amounts of fluid intravenously is likely to be destined to fail and may result in generalized edema, circulatory embarrassment and possible collapse. As advised by Coller and associates[18] it is safer to limit fluid intake to that which is required to cover actual losses, combat acidosis when it occurs and "ride out the storm" until the renal tubules begin to function again.

When renal output increases again, the urine output is likely to exceed the fluid intake (usually seven to 10 days after the burn). At this stage there is need for a large fluid intake and dehydration and salt depletion are to be guarded against. An intake of 6 or 7 L. a day may be required to avoid a deficit. The simple bedside urinary chloride estimations of Evans and Van Slyke[27] are of value in determining whether water replacement alone or electrolyte solution is required. The urine chloride estimation is much quicker and often more reliable than the plasma chloride determination.

During the phase of polyuria, anemia and hypoprotinemia are likely to develop rapidly unless replacement therapy is adequate.

Local Treatment of the Burn. Assuming that the considerations discussed in the previous section on shock and fluid balance have been met, the following procedures are carried out in order. Each step is carried out quickly and with minimal trauma. No anesthesia is used except under unusual conditions. It is expedient that all necessary supplies and equipment be centralized on a movable table or cart in order to minimize delay or interruptions.

1. Morphine is administered for pain when indicated, not routinely. It is administered intravenously in order to act quickly and minimize late depressant effects.

2. Under strict asepsis grease or oil are gently removed from the burned surface with an appropriate solvent. The area is then cleansed with plain soapy water (not green soap), then flushed with sterile saline. Small blisters are not disturbed; large blebs are evacuated in the interests of comfort; vigorous scrubbing is not permitted.

3. Strips of fine mesh cotton or rayon gauze are layed over the burned surface, followed by heavy rollers of coarse mesh gauze. A full-thickness sheet of sterile absorbent cotton is applied overall, secured with an evenly applied, snug bandage of cotton or elastic material. If an extremity is nvolved, it is covered completely. Fingers are padded to maintain position of function. If an elastic bandage is used, great care must be exercised to avoid making the dressing too tight. The term pressure dressing must not be interpreted too literally.

4. Mucocutaneous junctions and genitalia are greased with sterile petrolatum.

5. Antibiotics are not given at the outset unless the patient is to be transported for long distances without constant observation.

Changing the Dressings. The time for a change of dressing has been the subject of much controversy. Experience has shown that there can be no set rule. With superficial burns, the dressings may remain undisturbed as long as they are dry and clean and as long as the patient's temperature is normal. The surface will often be healed at the time of the first dressing. With deep second and third degree burns, the dressings are likely to become saturated with exudate somewhere between the fifth and tenth days and the patient's temperature rises. It is to be assumed at this time that infection is present and to leave the dressing undisturbed is dangerous. The method of control of infection may be one of the following: (1) Frequent change of dressings and antibiotics systemically. This method depends upon mechanical cleansing to control infection locally. Frequent tub baths may assist with

the mechanical cleansing but are not always well tolerated by very sick patients and are not practical in the field. (2) Continuous Dakin's solution dressings, with or without systemic antibiotics. (3) Delayed surgical débridement and skin graft as advocated by Allen.[4] (4) Antibiotics and chemical débridement by an agent such as pyruvic acid, recommended by Connor and Harvey.[19]

Comment. Frequent change of dressing is adequate when burns are relatively superficial, necrotic tissue is minimal and there is a low grade infection. When slough is deep and infection considerable, however, no generally applicable method has been found as satisfactory as the Dakin's dressing which combines bacterial control with ability to dissolve slough and exudate. Surgical débridement and graft is safe only on exceptionally well organized services staffed by surgeons who are able to operate rapidly and with minimal trauma. Chemical débridement has thus far not proved practical for general use.

Since it is this phase of burn treatment that is most often misunderstood and mishandled, in the experience of the author the following details are appended for emphasis.

Dakin's Solution Dressing. The hypochlorite solution must be fresh and of full U.S.P. strength since its bactericidal properties depend upon the available chlorine which is released quickly when in contact with tissue fluid.

The wound surface must be continuously wet with the hypochlorite solution. This necessitates a dressing which is frequently moistened by continuous drip or one in which evaporation is minimized by an impervious covering. The optimum is achieved by means of a heavy dressing of roller gauze, covered with a thick layer of sterile absorbent cotton bandaged on with even pressure and a covering of oiled silk similarly bandaged overall. This dressing is kept wet either by a continuous drip or by wetting it thoroughly with fresh Dakin's solution every four to six hours and again bandaging on the oiled silk cover.

The dressing is changed often enough to get rid of necrotic tissue as it separates, usually every twenty-four to forty-eight hours.

Pain is minimized by protecting normal skin with sterile petrolatum and applying a lattice work of petrolatum or xeroform gauze over the burned area. When the dressing is changed, it is also helpful to apply the roller gauze that goes next to the wound wet with sterile saline. The entire dressing is then wet with Dakin's solution a few minutes later.

If the dressing is stained green by pyocyaneus exudate, it is to be assumed that the Dakin's is below U.S.P. strength or has been improperly applied.

It is essential that a method of burn treatment be used which will prepare the denuded wound for skin grafting at the earliest possible date. Using effective Dakin's solution dressings on an extensive burn, this optimum can usually be accomplished in from three to ten days.

MAINTAINING A GOOD NUTRITIONAL STATE

During the later stages of burn treatment if secondary anemia and hypoprotinemia are permitted to exist the wound granulations become edematous, bleed easily—sometimes dangerously—and epidermal growth is arrested. Repeated blood transfusion and a high protein intake are always necessary at this stage. The protein intake should be from two to three times the requirement of the normal individual to compensate for the loss of tissue protein from the large wound. The importance of this requirement cannot be overemphasized. The amino acid preparations now available everywhere are helpful in accomplishing this purpose. A normal plasma protein determination may be misleading in the presence of anemia. Lund[33] and Siler[42] have called attention to the importance of maintaining an adequate vitamin intake, especially that of ascorbic acid, a dosage of 1 Gm. or more a day of the latter being recommended.

SKIN GRAFTING OF LARGE BURNS

When the patient has survived the early critical stage of the burn, every effort of the surgeon is directed toward closing the wound with satisfactory skin at the earliest possible date in order to minimize the threat of nutritional deficiency, late infectious complications and the crippling effects which accompany excess scar formation.

The type of graft should be applied which will cover the denuded area rapidly, with least threat to the life of the patient and with the best chance of providing a permanently satisfactory surface. Small, deep (pin point) grafts almost never meet these requirements and deface donor sites inexcusably. Large sheets of

split-thickness skin, on the other hand, are cut rapidly from almost any donor site and can be applied with a high degree of success. The resulting skin surface is usually permanently satisfactory.

The granulating bed of the wound is shaved down to normal subcutaneous tissue before applying the grafts. The grafts will take on a thick bed of granulations, but the resulting skin will be deformed by the underlying fibrous tissue. Applying the grafts to subcutaneous tissue of normal texture insures smoother, evener skin.

When the denuded area is large and the donor sites are limited, the sheets of skin must be stretched to the limit, both figuratively and literally. The life of the patient or the function of a limb may depend upon early closure of the wound. By tacking large sheets of skin together and suturing them to the wound margins under stretch, maximum coverage is obtained with minimum hazard of failure.

If the wound is completely covered by the grafts, either wet or dry dressings may be used satisfactorily. If, however, there are open granulations adjacent to the grafted area, the margins of the latter are protected by keeping the dressings wet with Dakin's solution for several days after the first twenty-four hours. Penicillin, given systemically both before and after the graft is performed, definitely increases the percentage of perfect takes.

It is just as important to maintain blood and protein balance after the graft as before.

MANAGEMENT OF BURNS IN THE ARMED FORCES

Burns represented a relatively small percentage of all casualties in World War II. Atomic warfare presents the probability of a larger percentage of burns in the event of future conflict. Burn treatment during the past war was not well organized. It would be fair to state, however, that the confusion that existed in the medical services of the armed forces was shared by the medical profession at home. In retrospect, it seems likely that the shock phase of treatment was fairly well carried out during the latter part of the war and at least some of the local, primary treatment of the burned surface was well done. The final stages of reconstruction to correct burn deformities was exceptionally well carried out on special plastic services. The weakest link in the chain seems to have been the management of the infected wounds resulting from deep burns.

Experience seems to indicate that the overall treatment of burns has been best in hospitals where groups of surgeons have formed teams to coordinate the treatment. The same principle should be applicable to our military forces.

The simple outline of burn management which has been described on the preceding pages could be adapted to field conditions in any overseas theater of operations with ease. The primary treatment could be handled admirably by a shock team in any forward unit. The badly burned patient should, of course be retained in the forward unit until stabilized, along with other categories of major injuries involving shock. By the third day it will usually be safe to transport the burned patient by air to a fixed installation where he could be under the supervision of an experienced burn team composed of surgeons selected for their understanding of wound management and for their skill in grafting large wounds. The patient should then remain with the burn team until his wound is closed. When an evacuation line required more than two or three days of transportation from the forward unit to the burn team, evacuation should be by hospital ship where the patient can be under the observation of a surgeon of similar training and experience to those composing the burn team. It is believed that such a plan would considerably reduce the morbidity from burns, it might reduce the mortality appreciably and it would certainly enhance the patient's chance of making a complete functional recovery.

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TRAUMA RESULTING FROM ATOMIC EXPLOSIONS

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IF two atomic bombs can kill 80,000 people and injure another 80,000, if it is still remotely possible that they will fall again on our own land or elsewhere, perhaps in greater numbers and with greater power of destruction than was the case three years ago in Japan, then it is proper that this Society hear something about the trauma caused by these explosions.

Let us form three concentric circles at half-mile intervals so that the smallest has a radius of one-half mile. The center of these three circles is the zero ground point, that is, the point directly below the point of the atomic explosion in the air. This division is, of course, quite arbitrary and the generalizations as to trauma in the three circles are not strictly accurate. In all of the five explosions for which data have been published many peculiar things happened: there were local points of greater destruction at greater distances and some points of less damage at lesser distances, but in general the inverse square law as to decline of force (and damage and trauma) with distance increase applies, and this rough division of distances is a very convenient one in which to group the types of trauma.

In the small center circle there will be practically no survivors. The people in it will be, so to speak, killed three times over—(1) by the direct blast or by being struck with flying objects, by being crushed in collapsed buildings, by being flung against buildings, walls, trees, etc.; (2) by burns, direct burns from the heat of the explosion or by being caught in buildings set afire by the heat of the explosion; (3) by radiation. In the middle ring (from one-half mile to one mile from the zero ground point) there will be (1) much fewer blast injuries; (2) the flash burns will be just as numerous but mostly non-fatal although deep enough to produce a great crop of keloids a few months later; (3) there will be thousands of deaths from radiation as well as thousands of non-fatal radiation victims. In the outer ring (one mile to a mile and one-half) the injuries will be limited mostly to non-fatal flash burns. Some mild flash burns will occur at distances even beyond the two-mile zone.

Most of the severe and fatal blast injuries will be from falling and flying débris. Actually there were, both in Japan and among the animals at Bikini, comparatively few cases of ruptured viscus and in Japan, at least among the survivors, even the occurrence of ruptured ear drums was rare. Evidently the earlier estimates of this type of trauma were quite exaggerated.

The flash burns will show some very queer patterns. This is an instantaneous type of exposure. White cloth will protect better than black cloth so that the print patterns of women's clothing will be burned on their bodies. Among some allied prisoners of war at Nagasaki, working two to three miles from the explosion, we saw cases in which their names had been burned onto their chests or backs because the names had been stenciled in black on their white undershirts. Clothing is an excellent protection against flash burns at distances of one to three miles from the explosion. The light and heat of the flash are so intense that it is almost as though a piece of the sun were suddenly transported to this planet. In fact, at Bikini the air burst viewed at twenty miles looked very much like a huge and very rapidly rising sun over the horizon of the sea. Viewed at that distance and through dark goggles so thick that objects cannot be distinguished at three or four feet it is a brilliant flash.

The temperature at the center has been estimated at a million degrees centigrade. At two miles the Japanese physicists and chemists estimated the temperatures to be from 3,000 to 9,000 degrees centigrade. These estimates were based on the melting and charring of certain substances at that distance. Telephone posts were charred and fires were started in some areas at distances beyond two miles. The skin burns varied (according to distances from the explosion) from mild erythemas to serious third degree burns followed by the usual granulating wounds, contractures and keloids.

The pathology of ionizing radiation has become a very large subject in the last three years and can only be touched on here. All of the radiation lesions seen in the Bikini animals have been reproduced later in other animals of the same species by x-ray alone. The immediate radiation fatalities, occurring in Japan in the inner circle, were doubtless from neutrons while those at greater distances and with symptoms appearing after an interval of one to several days were the result of gamma ray exposures. The alpha and beta radiation injuries can only occur as results of underwater explosions when the victims are sprayed or come in contact with objects that have been sprayed with water containing the fission products of the explosives. In the air bursts these products rise quickly in the atomic cloud to heights of many thousands of feet and are dispersed in the stratosphere, except in the most unfortunate circumstance when a heavy rain fall catches the atomic cloud before it has dispersed and may carry to the earth a rain of death drops in the form of intensely radioactive fission products.

The chief trauma from radiation is in the hematopoietic and lymphatic systems. Aside from those dying in the first day or two, the highest death rates will be seen in the third and fourth week. The prognosis for those entering hospitals with radiation sickness after the fourth week will be increasingly favorable. The clinical course will include nausea, malaise, anorexia, diarrhea, all the signs of extensive hemorrhage (into stomach, bowel, kidney), purpura and epilation. The laboratory findings will include leukopenia, anemia and increased bleeding time. The one quick, early and reliable finding is leukopenia, the extent of this drop being a valuable prognostic index. In severe cases the count goes below 1,000 and in fatal cases may even reach zero before death occurs.

The only good prevention is to be at a distance of at least five miles from the explosion. With the later bombs, this distance may have to be increased. No public information has been released on this point. At much shorter distances survivial or even complete protection may be possible under ideal shelter conditions.

As to treatment of radiation victims this of necessity becomes a mass problem rather than any individual case problem. It will require highly organized and well trained rescue teams and a catastrophe hospitalization program that must include an enormous blood bank system. Whole blood is the only effective agent yet known for life saving purposes in radiation sickness.

Casualties of all types will be found in an area of 8 to 10 square miles after an air burst and about 15 square miles after an underwater burst. The water spray actually covers an area of some 30 square miles but half of it will be out over the lake or outer harbor where there will be few or no people. Rescue squads can enter the air burst area almost immediately after the explosion but, following an underwater burst, the problem becomes very complex—much too involved for a discussion of this length.

DISCUSSION OF PAPERS BY DRS. LIVINGSTON, DEARING, GLOVER AND PARSONS

VINTON E. SILER (Cincinnati, Ohio): Dr. Glover has given a very fine discussion of the present status of burn therapy and I would like to re-emphasize one of the points which he made in his paper, namely, early application of skin to the areas of total skin destruction. It seems to me there are four reasons for the delay of early skin grafting:

The first one is that wounds produced by a burn are frequently extensive and because of the poor general condition of the patient from this type of trauma grafting is delayed.

The second reason is that the area of total skin destruction is composed of sloughing tissue which is difficult to remove and grafting cannot be done until the wound is adequately prepared. There are essentially two methods now available for the removal of this slough, these being physical and chemical methods. The physical methods have been discussed by many observers throughout the country during the past five years. One of the first to discuss this method of removal of sloughing tissue was Young; however, Cope, McCorkle and others have helped to popularize this technic. In this procedure the patient is usually given a general anesthetic and the area of slough is actually excised down to and often including normal tissue. The general condition of the patient is usually good; however, this factor governs the extent of débridement and also the optimum time for it. If the area of sloughing is extensive, this procedure is usually best done in stages. Grafting has been done both immediately and delayed after this procedure.

A chemical approach to the removal of sloughing tissue is sound and ideal. We have been interested in this problem for many years and during the past year particularly. I cannot go into all of the details here except to say that the ultimate answer to this

problem may lie in the realm of proteolytic enzymatic activity. During the past twelve months in the laboratory we have been able to remove sloughing tissue on a dog, created by a heat burn, without apparent damage to living cells. The most rapid removal has been twenty-eight minutes; however, the average time has been between one and two hours. At present, working with Drs. Logan and Tytel in the Department of Biochemistry, we have found a collagenase which is very active and at least fifty times stronger than the proteolytic enzymes of pancreatic substance. The problem confronting us at the present time is to find an enzyme which will attack the keratins of the skin to the same degree that the collagens are destroyed. I am sorry to say that at the present time we have not solved this problem.

The third reason for delay of early grafting is frequently due to severe infection of open wounds. I agree with Dr. Glover, as I am sure others do, that Dakin's solution is the best method of bringing these infected wounds under control. We have found that by using Dakins' manifold tube in a semipressure dressing and leaving the dressing in place for some three to five days we have been able to control infections of these wounds much better. In this instance the solution is instilled to the manifold tube every three to five hours.

Last, but certainly not the least of the four reasons, is delay in grafting because of the indiscriminate procrastination on the part of the surgeon. We have found it particularly true in our own hospital that residents are more apt to be interested in doing major surgery such as subtotal gastrectomy, splenectomy or other similar operations than they are to concern themselves with the early closure of large open wounds. I am convinced that this type of procrastination should be corrected.

GROVER C. PENBERTHY (Detroit, Mich.): The history of burns as Dr. Glover has reviewed it is most interesting, and all of us in the past thirty years have seen great changes and great improvements but we still believe that there is room for more improvement.

With the mortality figures as he has given them, prior to the tannic acid or coagulation period (and he has compared them with the present type of therapy), they show something which I do not think he emphasized too strongly: that it does not all depend on local treatment. We do appreciate and know that a burn is a surgical wound and must be treated and the principles of good general surgery must be instituted, but it shows from the mortality figures reported in the various clinics that it is the general systemic treatment which after all, in addition to the good surgical local treatment, helps to maintain our low mortality.

Dr. Glover mentioned the fact that fluid therapy must be based on careful blood observations, the renal output and the general acumen of the individual surgeon. That is a very sound principle to follow in the management of this type of lesion.

He has referred to Dr. Coller and his associates in their work in limiting the amount of fluid that must be given parenterally. Simply maintaining what is actually lost has been proven by Dr. Coller and his group to be all that is necessary. They emphasize, however, how important it is for oral intake in preference to the intravenous route, and that is something I am sure all of us will support as an idea in maintaining fluid balance.

The teamwork, as Dr. Glover has said, is of great importance, and I am sure with what experience we have had in the various clinics we are ready today to meet the problem of burns with a team fully equipped to take care of that burn patient. It maintains the interest of the house staff. Dr. Siler said they would rather do gastric resections and other major operations. It falls to the attending staff I think to stimulate the resident and intern staff to maintain their interest in this subject, the treatment of burns.

With that I am sure we can maintain the low mortality we have, and for the future still bring the mortality down to a much lower figure.

HERBERT M. ELDER (Montreal, Canada): Dr. Glover mentioned the transitional period through which he and we went, and I had the opportunity of seeing part of that. In 1939 we were all indoctrinated with the idea of the coagulation treatment of burns. That continued in 1940, and 1941 for a time. I had the opportunity then of seeing McIndoo's work at a burn center established by the Royal Air Force where most of the severely burned pilots of the Battle of Britain were sent. They were all very similar burns.

The Spitfire at that time was about the only plane we had, and at that time we did not have a self-sealing tank. The tank was across the cowling in front of the pilot. The consequence was that if that tank were hit by an incendiary the pilot had just about ten seconds to "hit the silk," and he was always badly burned during those ten seconds.

It became known as a pilot-officer burn—both hands, the face and the thighs. McIndoo set up the first of the various units which had a good deal to do with the change in that treatment. He turned to the continuous bath treatment. Originally one saw these people treated with tannic acid, particularly on the moving parts. If you have ever seen a badly burned hand treated with tannic acid, with the knuckle bones showing white through the scar, you will never want to use tannic acid again. We had to take tannic acid out of our tank first aid kits. The anticoagulant on any moving part was definitely taboo. The saline bath came into vogue and now we are in the pressure dressing era.

I would like to emphasize that the pressure dressing cannot be applied by any neophyte; it is

not a simple matter and it is not something that is just pushed on the patient. It has to be very carefully applied. The pressure has to be even, else one will get extremely bad results. One of the previous speakers mentioned the overemphasis of pressure leading to ischemia, Volkmann's paralysis and so on.

Secondly, from a purely military point of view the pressure dressing is not always a good thing for the transport of patients because sometimes they are placed in attitudes which produce creases, and those creases will sometimes produce so much pressure as to produce necrosis.

I think before going overboard on pressure dressings we have to consider some of those points; we should use the pressure dressing with a good deal of respect and not consider that it is the be-all and end-all.

STEPHEN A. HUDACK (closing): I believe I express the sentiments of the members of this Association when I thank the individuals who have given papers on this symposium on military surgery. I would like to emphasize that I have known all four of them personally for some time.

I worked with Dr. Livingston on the west coast, collaborating with him on some of the complex reconstruction problems which involved both injury to the peripheral nerve system and the motor skeletal system.

Admiral Dearing packs behind his discussion the shoestring brigade. He was the senior medical officer responsible for evacuation of troops serving with the Third Fleet with Admiral Halsey in the South Pacific force, and I am sure in the early period he labored under many disadvantages, being told sometimes that bullets and beans were more important than something else.

Dr. Robert Parsons is a gentleman of many accomplishments, not chief of them being that he was the senior medical officer of the U.S.S. Haven, which was actually the first ship to hit Japan, and they did their observing at Nagasaki about one month after the explosion of the bomb. Their ship was the one to evacuate the war prisoners and screen approximately 10,000 of them, of which 1,000 were taken aboard. Officially he was an observer on the radiologic safety ship in the observations at Bikini during the atomic bomb tests.

I believe the wide experience these speakers carry should have some weight in any deliberations that this body may think fit to carry through in any form of recommendations.

ARTHUR H. DEARING (closing): In the early days of the war in the South Pacific there was some dissension and feeling of jealousy between the Army and the Navy. It has been my feeling on the subject that when the reserve officer comes on active duty we should no longer speak of him as a reserve and we should not have this discrimination or this talk about regulars and reserves.

I have heard of Dr. Livingston's unpleasant experiences, and I know that there are many other medical officers who are now on inactive duty and some who are still on active duty who had unpleasant experiences during the last war. They were bound to! You will always find people who will be unpleasant to other people in any walk of life. It does not hold true particularly of doctors, I am sure.

Dr. Livingston survived those unpleasant experiences and I am sure his paper does not represent bitterness on his part in speaking of them. It is an honest attempt to lead all of the medical profession into some line of planning which will be beneficial to the whole country in case of another war.

People talk about the officers in uniform being warmongers. We are not warmongers; we do not want war but we have got to face the possibility, and I am sure that after hearing what Captain Parsons has said about the possibilities of atomic warfare and the fact that we realize that if there must be another war this country will not be immune as we have been in the past but that it will undoubtedly mean war on our shores, then the planning for medical defense and the planning for care of casualties is going to be a problem, and a problem for the entire medical profession. It cannot be left to the military or the naval services or even to the Office of Civilian Defense. It is a problem for every one of us to think about before war comes.

NATURE OF TRAUMA IN ATOMIC WARFARE

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IT may appear remarkable for an internist to speak on the subject of trauma but the development of the atomic bomb has resulted in a form of mass physiologic trauma with which most of us were hitherto unfamiliar. In addition to this many of the more familiar forms of trauma are attendant upon the explosion of the bomb.

Our attention was first called to the atomic bomb because of its explosive force which exceeds that of traditional explosives by tens of thousands of times. Trauma to individuals in the area blasted by the atomic bomb includes injuries by flying glass and falling beams, etc., which are seen in the wake of any high explosive or similar major accident. The traumatic effect on structures by the atomic bomb of the style which was used at Hiroshima and Nagasaki is, however, unusual in certain respects. For example, at the Nagasaki bomb center one sees small concrete buildings which appear to have been crushed by a single blow from the direction of the bomb. The Nagasaki bomb was set off in an area of military importance from all points of view halfway between a large steel works and an ordnance plant some distance from the center of the city and around a mountain so that the major part of the city was spared. Between the steel works and the torpedo works which were about a mile apart a civilian community of some size and the Nagasaki Medical School and Hospital were located. I mention that to bring home the fact that in striking for definitely military objectives in the past war and no doubt in wars of the future the general population will be involved in large measure.

The Nagasaki Medical School was a few hundred yards from the point above which the bomb went off. The inside of the building was largely burned out. Less than half of the inhabitants of the building survived and one of the two tall smoke stacks was left inclined away from the bomb center. One of the professors of the Nagasaki Medical School who was suffering from chronic myeloid leukemia and had not been responding very well to radiation therapy enjoyed prolonged remission as a result of the radiation received at the time of the blast.

At one of the Shinto shrines near the medical school one-half of the traditional stone arch was blown away leaving the other half balanced precariously and the solid stone lantern, lighted at times for the spirits of the dead, was moved over several inches on its pedestal. This shows the effect of the blast wave transmitted through air. A nearby large tree, though still standing, was dead as a result of the heat. In many places, particularly in the Hiroshima bomb field, one can see charred structures in which unburnt areas represent the shadows of leaves or plants and sometimes of human beings. The charring occurred instantaneously from thermal radiation; the shadowing objects were destroyed at once or blown away. From this thermal trauma burns of all degrees resulted, many of which were followed by keloids. These appear on only one side of the body and avoid protected areas; hence, they can be distinguished from those resulting from flash burns. We are told that keloids occur more often in scars in negroes than in white individuals; also that these lesions are more common in wounds which are contaminated or are secondarily infected. The reason for their extremely high frequency among Japanese after atomic bomb burns is a little uncertain, but of the late effects of the atomic bomb on men, probably the most noticeable which is seen after a year or more is the presence of keloidal scars in a large proportion of the individuals who were exposed. This is true to such an extent that they are a common sight on the streets of Hiroshima and no one is thought to be unusual if he bears keloidal scars.

At the moment of explosion the atomic bomb gives off intensely almost the entire spectrum of electromagnetic radiation including visible light. The Japanese colloquial term for the atomic bomb is "bright light." Radiant heat and ultraviolet light are also given off. Individuals who were ten miles from the experimental atomic bombs felt a wave of fairly intense heat momentarily on the exposed parts

of the body. How much ultraviolet light has to do with the late lesions is uncertain; evidence indicates that this is due to a nearly instantaneous, very intense wave of infra-red radiation or radiant heat. Studies have not yet indicated what the racial susceptibility of the Japanese to keloidal reactions is relative to our own. The response to an identical physical stimulus can be seen where numbers of persons were near the same place at the time of detonation. The degree of scarring or keloid formation varied widely between individuals; in some groups receiving the same exposure the range of susceptibility varied from extensive keloids to no visible scarring. We must remember that patients were treated under very primitive conditions because of the general disorder which prevailed, so it is almost certain that the majority of these lesions became infected and remained infected over a considerable period of time.

In general treatment of keloids has been quite unsatisfactory. Surgical removal often results in recurrence. One patient who was treated surgically for keloids of the legs below the knees had pinch grafts taken from the thigh and the area from which the grafts were taken showed multiple keloids where skin was removed from that area. This patient had a scar from an earlier operation which healed without a keloid. One treatment which has been recommended for keloids is x-ray therapy. There has been a natural reluctance to use this on the skin of those individuals who were exposed to the atomic bomb although I believe that most of the patients were far enough from the bomb so that the dosage of radiation they received from that source was relatively unimportant.

Another effect of the heat was to set numerous fires and one, therefore, can see in the bombed areas of Nagasaki and Hiroshima a picture very similar to that seen in other Japanese cities which were bombed with incendiaries where great areas were burned out. I mentioned the fact that bomb fields were the scene of great confusion from medical and surgical points of view immediately after the bombs fell. It is of some interest to see the conditions still prevailing. For example, due to stringent rationing it has been almost impossible to solve the problem of feeding patients in the hospital. It has been necessary to require that the families of patients bring in their rations, which are prepared at home, and feed them to the patients. In a typical ward in one of the better hospitals eighteen months after the war was over we saw patients' meals being prepared over hot charcoal in the ward by several members of their families.

The confusion immediately after the bombing is difficult to imagine. Besides the forms of injury mentioned before, radiation disease is a new and peculiar form of trauma which has attracted special attention and was soon called "atomic bomb disease" by the Japanese. Radiation from the bomb consists of gamma rays which are entirely equivalent in their effects to x-rays and neutrons which, qualitatively, are also quite similar to x-rays except that they may also induce radioactivity in many normal elements. Induced radioactivity was an insignificant part of the total radiation. Acute radiation sickness is the result of exposure to these energies which are essentially the same in their effects as total-body x-ray.

Soon after the exposure to atomic bomb radiation an initial response occurs which is quite similar to that after a large dose of total-body radiation or a somewhat larger dose of localized radiation to the abdomen in patients who are being intensively treated. One sees vomiting and depression in blood pressure which may be due, in part at least, to stimulation of the parasympathetic system. This passes off within a few hours. After this the radiosensitive tissues and cells are atrophied and destroyed. The blood-forming elements, bone marrow and lymphatic tissue atrophy rather soon. Intestinal mucosa, which is also a tissue of rapidly dividing cells, suffers destructive lesions and ulcers appear. The gonads are atrophied; hair falls out and various other pathologic findings are seen but those are the ones which give the most prominent visible phenomena. When all these things occur, the first visible result is a decrease in the white cell count. Patients are innocent of any impending disease; they are apparently healthy when the transitory phase of acute radiation sickness has passed. Therefore, many individuals who were exposed to bombs and who may or may not have suffered temporary debility went to other places.

One visitor to Hiroshima returned to Tokyo and after a few days became acutely ill. She had petechial hemorrhages under her skin, bloody diarrhea and fever. All of the following

were secondary effects of destruction of the radiosensitive cells: the hemorrhagic diathesis resulting from the destruction of the mast cells which released heparin into the circulation and from disappearance of platelets from the circulation; infection from the lesions in the intestinal mucosa and the failure of white cell formation. Other factors in the radiation syndrome no doubt remain to be understood. The patient died of acute radiation disease approximately two weeks after the bombing having, in the meantime, moved around quite freely. Thus we have the picture of a patient who is apparently perfectly healthy and then, while going about his business succumbs to the delayed effects of trauma to certain radiosensitive cells.

Other patients who recovered from the acute phase developed a subacute state characterized by aplastic anemia. Red cells remain in circulation much longer than white cells; therefore, anemia develops slowly over a period of weeks. At the time when the first American expedition went into Japan almost all of the patients with fatal acute radiation sickness had died and the chief residual clinical picture was one of aplastic anemia, some of which recovered.

There is also the question of sterility. This is produced by a lower dose of radiation in the male than in the female but is usually temporary and as far as available information goes most of the Japanese males who were rendered sterile by exposure to the atomic bomb and who survived the amount of total-body radiation recovered their fertility within a few months. Much of our information has been derived from vital statistics at Hiroshima. The fact that for a period corresponding to two months after the bombing the birth rate dropped and then rose again might be due to the temporary sterility produced and, on the other hand, might be due largely to the general confusion which resulted from the bomb.

One small area some distance from Nagasaki which was shaded from the bomb by a mountain received ground radioactivity from uranium fission products deposited upon it. This was a very small proportion of the total radioactive material because the bombs were carefully set off at such a height that the fission products were carried up into the higher atmosphere. We know from the second Bikini experience that it would be possible to set off a bomb under water or under other conditions so that the fission products would be trapped near the ground; in that way at least the equivalent of thousands of tons of radium would be scattered on the ground. This would institute a late traumatic effect which is no longer in any sense acute but which can be the cause of total-body radiation of persons coming into the area later, picked up by individuals in the area. These fission products can also be taken into the body and after absorption act as radium does. If they are carried to the bone, as many of the more abundant fission isotopes are, the eventual end result is destructive lesions in bone and malignant bone tumors. These hazards did not exist in the Japanese areas due to the very small (although measurable) portion of the radioactive material involved.

The most delayed effect of the atomic bomb about which there has been much speculation is the genetic result of induced mutations. There is no reason to believe that any immediate deleterious effects have occurred. Available vital statistics indicated that in the year and one-half after the atomic bombing, of Hiroshima there were for the most part no abnormally born children. Reports were obtained of two anencephalic fetuses during that period and also of two babies covered with hematomas who were born of mothers suffering from acute radiation sickness soon after the bombing. There is no doubt that genetic changes in later generations, due to recessive mutations, will occur as a result of radiation in a slightly higher proportion than normal. There is a great deal of doubt, however, as to whether the normal incidence will be sufficiently increased to be visible regardless of the completeness of the statistics because the effect will be relatively small. Mass sterilization, although a possible solution to the impending catastrophe of world overpopulation, also will probably not be significantly effected by the atomic bomb.

I am going from the familiar and, to most of us, the commonly-thought-of types of trauma to a larger field. It seems appropriate to discuss the psychic trauma to individuals and the social body in connection with this subject.

It was, in fact, recognized by the Japanese scientists almost at once that the Hiroshima disaster was caused by an atomic bomb. One physicist was given six months by the army to

develop one and politely declined this impossible order. He was then asked how Japan could be defended against atomic bombs in the future, and replied, "That's very easy. Just keep airplanes from flying over Japan and then you will be sure that no airplanes with atomic bombs will fly over Japan." Three hours after this information was given to the chiefs of staff, surrender was agreed upon. Whether other factors influenced this decision is, of course, not known.

A few comments are in order about the essential difference between the atomic bomb and the ordinary types of warfare. It certainly is not a matter of mechanical trauma, burns or radiation although the latter, which is a very interesting characteristic of the bomb, deserves special attention. The really novel feature of the bomb from the strategic point of view is that when it strikes, a large area is immobilized. I think our experience with local bombing by high explosives dropped here and there even in saturation bombing is that there is a recovery period. People can get out or in and things can be moved around.

In the case of the atomic bomb the problem is somewhat different in that a large area is wiped out instantaneously and in the case of both Hiroshima and Nagaski hospitals were immobilized at once all over the cities, a large number of the doctors and nurses were killed or put out of useful circulation, water mains were broken, communication was completely interfered with and there was no way of getting into the centers. Thus, the army pilot who flew from Tokyo to Hiroshima to investigate why the radio station had gone off the air and other communications were broken found a city surrounded by a circumference of flame two or three miles from the center of town and was unable to get in. A few people managed to drag themselves through the flames, and these stragglers turned up at Kure, thirty miles away, telling a remarkable tale to listeners who had only seen the bright flash in the sky.

A situation in which an entire region is put out of commission and in which it is impossible to get around is one which has not been seen in its ultimate state of development in past warfare where destruction occurs gradually and one area recovers as another one goes down. For this reason in particular we must plan now for a civilian defense organization able to assume new responsibility hitherto unnecessary. It will have to learn in advance of a catastrophe how to operate under conditions of great and sudden civic disruption and must have the equipment and knowledge to determine the importance of such ground radioactivity as may be encountered. For the residual radioactivity of a bomb blast set off in water might be enough to require rapid evacuation or it might be as harmless as that on a luminous watch dial or that which was deposited near Nagasaki. In the latter instance the panic engendered in the population might be in itself the major problem. Rumors regarding possible radioactivity at dangerous levels in Japan, some of which originated in this country, still persist among the Japanese. Problems of future war and most particularly of atomic warfare will find one essential answer in the better education of specialists and the public alike to an objective appreciation of possible situations which may arise and to the development of a civilian defense organization which not only is equal to the problems of the past but can apply foresight and wisdom to the problems of future war.

In closing I should like to mention briefly the treatment of the radiation syndrome. Much of the treatment of radiation sickness is very similar to the general non-specific treatment of traumatic conditions. Patients will also have been subjected to burns and mechanical trauma as well as radiation. The use of plasma and whole blood and antibiotics will be indicated from all points of view. There are certain specific agents which will help in maintaining the life of individuals who have been heavily radiated. Toluidine blue and protamine are known to affect the bleeding tendency favorably and progress is being made in the search for other specific agents. The position of rutin and of adrenal hormones in therapy of the radiation syndrome is questionable at the present time. In general the use of blood substitutes soon after radiation with therapy directed to combating infection when signs of sepsis appear and replacement of whole blood when anemia develops will follow a pattern familiar to the traumatic surgeon.

MASSIVE EXTRADURAL HEMATOMA*

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EXTRADURAL hematoma remains one of the most deceptive and lethal lesions in the surgical field. The results from timely and well executed surgery are so brilliant and consequences from improper handling so disastrous it seems justifiable to review some of the problems encountered in these cases.

Numerous authors have published the mortality among their patients with extradural hematomas. Pringle[1] in 1938 stated that eleven of his seventeen patients (64.7 per cent) with extradural hematomas died. In another group of his patients, eleven of sixteen (68.7 per cent) who had concomitant extradural and subdural hematomas did not survive. A review of Pringle's[1] cases reveals that many of his patients who had extradural hematomas also had extensive cerebral laceration or injury elsewhere such as a ruptured abdominal organ. McKenzie[2] in 1938 reported a 45 per cent mortality among twenty patients; part were postmortem cases and part surgical. Munro and Maltby[3] published their results in forty-four cases, thirty-eight of which were surgical and six postmortem. Twenty of the thirty-eight surgical patients died (52 per cent mortality). Adding the six postmortem cases to the twenty fatal surgical cases, they had a 59 per cent mortality for the total series of forty-four patients. Woodhall, Devine and Hart[4] in 1941 published the results in 177 cases collected from the literature and stated that the mortality was 56.5 per cent. Gurdjian and Webster[5] in 1942 reported that of thirty patients upon whom they had operated eight died (26.6 per cent mortality). Sartorius and Humphries[6] in 1946 reported twenty operative cases of extradural hematoma with only one death (5 per cent mortality). All occurred in a mining practice among adult South African natives. These authors explain their low death rate by virtue of the fact that the injury in seventeen of the twenty patients was the result of assault and therefore cerebral damage, when present in addition to the clot, was focal in nature. A careful review of their case histories reveals that a majority of their patients arrived for treatment conscious and in good condition which is contrary to the experience of most surgeons reporting such cases in this country. For example, eighteen of the twenty-two patients which I am reporting in this series arrived at the hospital unconscious. All of the twenty patients who were operated upon in this series had become comatose before the operation was started and two of the twenty surgical patients stopped breathing before the operation was started and were operated upon under artificial respiration. In 1947 Voris[7] reported twenty-two consecutive operative cases; ten (45 per cent) died.

Not being satisfied with my own results I have undertaken a review of this series of twenty-two patients with extradural hematoma who have come under my care during the last ten years in the hopes that I might uncover my own errors and arrive at some conclusions regarding the steps which must be taken to give the patient who is suffering from this lesion his greatest chance for survival. All of the patients included in the series had massive hematomas which either caused death or seemed destined to produce death had they not been removed surgically. No patient was included in the series unless the presence of the hematoma was proved either by surgery or autopsy. During the ten-year period in which these cases were collected 1,763 patients suffering from head injury came under my care. Five hundred sixty were seen a month or more following injury; they sought consultation because of post-traumatic sequellae or complications. These were classified as "old" head injury cases and were eliminated in calculating the percentage of extradural hematomas occurring in a series of acute head injury cases. Thus, the twenty-two patients with extradural hematomas represented 1.83 per cent of my series of 1,203 acute head injury cases. Since it seems that a neurosurgeon's figures might be distorted by the probability that he sees an abnormally high percentage of head injury

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patients requiring surgery, I reviewed the head injury series at one of the hospitals (Good Samaritan Hospital) in which I work and found that in the ten-year period under consideration 1,317 patients with acute head injuries were admitted to the hospital. This figure included not only patients coming under my care but also those who came under the care of other attending physicians in that hospital. Among the 1,317 patients there were fifteen with extradural hematomas, representing 1.14 per cent of the total number of acute head injury patients. Both of these figures for the percentage of extradural hematomas are somewhat lower than that found by Munro and Maltby[3] who stated that extradural hematomas constituted 3 per cent of 1,200 head injury patients treated at the neurosurgical service at Boston City Hospital from 1932 to 1939. King[8] stated that extradural hematoma complicates craniocerebral injury in about 2 to 5 per cent of cases. The figures in my series of extradural hematoma cases may not be entirely accurate for possibly a few patients with extradural hematomas survived and left the hospital without surgery. On the other hand, I am fairly certain that no patient under my care died of extradural hematoma who did not come to autopsy. Of my twenty-two patients twenty were operated upon and six of the twenty died (30 per cent mortality). Two others were postmortem cases having never come to surgery. Thus there was a 36.4 per cent mortality for the total series of twenty-two patients.

Table I

SOURCE OF BLEEDING IN TWENTY-TWO PATIENTS WITH EXTRADURAL HEMATOMA

Middle meningeal or branch thereof	10
Transverse sinus	1
Emissary vessel (from bone to superior longitudinal sinus)	2
Indeterminate	9
Total	22

SITE OF BLEEDING

Various authors have pointed out that extradural hemorrhage may originate from (1) rupture of the middle meningeal artery or one of its branches; (2) tear of one of the dural sinuses; (3) tear of an emissary vessel or (4) bleeding from the diploic vessels. The exact source of bleeding responsible for the formation of the extradural hematoma is not always easy to find. In my own series the source of bleeding could be definitely established in thirteen cases. (Table I.) In ten of these the site of bleeding was the middle meningeal artery or one of its branches. A tear of the transverse sinus was responsible for the hematoma formation in one case and in two cases an emissary vein from skull to superior longitudinal sinus had been torn. In the other nine the source of bleeding was indeterminate.

Table II

LUCID INTERVAL IN TWENTY-TWO PATIENTS WITH EXTRADURAL HEMATOMA

Lucid interval	18 (81.8%)
Confused or unconscious since injury	3
Unconscious on admission—no history available	1
Total	22

SIGNS AND SYMPTOMS

Lucid Interval. Much has been written regarding the lucid interval which occurs in patients suffering from extradural hematoma. While the lucid interval is not absolutely diagnostic of extradural hematoma, it is a valuable point in favor of that diagnosis. The lucid interval may be obscured by contusion and laceration of the brain or by alcoholism. In this series of twenty-two patients eighteen were semiconscious or comatose upon arrival at the hospital. However, a history of a lucid interval was obtained in eighteen of the twenty-two (81.8 per cent), the history being obtained from a relative, friend or referring physician in most instances. (Table II.) One patient had been mentally confused during the six days between injury and his arrival at the hospital where he was operated upon while two had been completely comatose since injury. In these three cases, therefore, there was no history of a lucid interval. One patient was found alone in his wrecked car and was taken to the hospital in an unconscious condition. No history of any kind ever was available; even after the patient recovered he could supply no information regarding the accident.

Signs of Motor and Sensory Impairment. Since almost all patients showed impaired consciousness, signs of motor impairment were much more frequently demonstrable than sensory deficits. Thirteen of the twenty-two patients had weakness of one side of the body; in two instances the weakness was on the same

side as the hematoma while in eleven it was on the opposite side. (Table III.) Two patients had flaccidity of all extremities and two presented the picture of decerebrate rigidity. Five, so far as could be determined, displayed normal motor activity bilaterally. There were increased tendon reflexes on the ipsilateral side in two; in three the tendon reflexes were increased on the opposite side from the hematoma and there was a bilateral increase of tendon reflexes in four. One patient showed a decrease of tendon reflexes contralaterally and five had bilateral decrease of the tendon reflexes. The abdominal reflexes were contralaterally decreased in two patients and bilaterally decreased in five. In three of the twenty-two patients the Babinski sign was positive on the ipsilateral side, in six the reflex was contralaterally positive and in ten bilaterally positive. The Babinski reflex was negative in only three patients. A contralateral decrease in sensation could be demonstrated in only two patients. Sensation could not be adequately tested in the eighteen patients who were comatose on admission to the hospital. Jacksonian convulsions which are so frequently described as indicating the presence of an extradural hematoma were not observed in any of the twenty-two patients in this study.

TABLE III
SIGNS OF MOTOR AND SENSORY IMPAIRMENT IN TWENTY-TWO PATIENTS WITH EXTRADURAL HEMATOMA

	Ipsilateral	Contralateral	Bilateral
Motor Status			
Hemiparesis	2	11	
Flaccidity	..	..	2
Decerebrate rigidity	..	..	2
Tendon reflexes			
Increased	2	3	4
Decreased	..	1	5
Abdominal reflexes decreased	..	2	5
Babinski reflex			
Positive	3	6	10
Negative	..	..	3
Decreased sensation	..	2	

One may conclude, therefore, that a hemiparesis is a good indication that the hematoma is on the opposite side of the brain. On the other hand, the Babinski sign is so frequently positive bilaterally that its value as a localizing sign may be lost.

Eye Signs. The size of the pupils and their reaction to light change with the duration and severity of the cerebral compression. The pupil on the side of the hematoma usually dilates and becomes fixed to light; then as the cerebral compression continues the contralateral pupil also becomes dilated and fixed to light. Table IV shows the condition of the pupils at the initial examination after the patient entered the hospital. There was a dilated and/or fixed pupil on the ipsilateral side in eight patients and on the contralateral side in two. In two patients the pupils were bilaterally dilated and fixed at the initial examination but two more patients who had ipsilateral dilatation of the pupil at the first examination developed bilaterally dilated fixed pupils before surgery. One patient had contracted fixed pupils but no notation was made as to whether he might have had morphine before being sent to the hospital.

TABLE IV
EYE SIGNS IN TWENTY-TWO PATIENTS WITH EXTRADURAL HEMATOMA

	Ipsilateral	Contralateral	Bilateral
Pupils			
Dilated and/or fixed	8	2	2
Contracted and fixed	..	..	1
Discs			
Papilledema	..	..	2
Blurring of disc margins	..	..	4

Optic disc changes were thought to be present in six patients. In two children with huge extradural hematomas there was choking of the discs and in each instance the choking was present within seven hours after injury. In four other patients there was blurring of the disc margins but no elevation of the discs.

Vital Functions. The classical description of the changes which occur in the vital functions when there is brain compression from an intracranial hematoma is slowing of the pulse, increase in the blood pressure, decrease of the respiratory rate and a rise in temperature. If the pressure continues, the signs change and the pulse becomes rapid and thready, the blood pressure falls, respiration becomes shal-

low, rapid and finally Cheyne-Stokes' in nature and the temperature continues to rise. However, as indicated in Table v, these vital signs will not greatly assist the surgeon in determining whether to operate upon a patient whom he suspects has an extradural hematoma. Very few of the twenty-two patients in this series showed changes in the vital signs which were of diagnostic value.

TABLE V
VITAL SIGNS IN TWENTY-TWO PATIENTS WITH EXTRADURAL HEMATOMA

Pulse	
Slower than normal	5
Faster than normal	4
Blood pressure	
Higher than normal	7
Lower than normal	2
Respirations	
Rapid	4
Slow	0
Temperature	
Elevated (101.4 to 106.6°F.)	6
Subnormal	1

Skull Fracture and Pineal Shift. Eighteen of the twenty-two patients are known to have had skull fractures. A total of fourteen of the twenty-two patients had preoperative roentgenograms of the head while eight of the twenty-two were not x-rayed. Among the fourteen patients who were x-rayed ten had fractures on the same side as the hematoma. (Table VI.) In one patient the fracture was on the opposite side from the hematoma and in two there were bilateral fractures. In the two patients with bilateral fractures the hematomas were also bilateral. Therefore, thirteen of the fourteen patients who were x-rayed had roentgenographic evidence of skull fracture. In five of the eight patients who were not x-rayed skull fractures were found at surgery or autopsy on the same side as the hematoma. X-ray evidence of a pineal shift was found in only two of the fourteen patients.

Cerebrospinal Fluid Findings. Twelve of the twenty-two patients had preoperative spinal punctures and in eight the spinal fluid pressures were above normal. (Table VI.) In one the pressure was subnormal and in three the pressure was within the range of normal. The appearance of the spinal fluid was recorded in ten instances. Eight times the spinal fluid appeared bloody and twice it was clear.

Signs and Symptoms in Young Children. Some comment should be made upon how frequently the "classical" signs and symptoms of extradural hematoma are seen in young children when apparently no hematoma is present. The following case is illustrative.

On June 7, 1948, R. B., a three and one-half year old boy, fell from his tricycle and struck the left side of his head. After a lucid interval of about two hours during which he cried most of the time he became drowsy and was taken to the hospital. About the time he arrived at the hospital he stopped breathing and had right-sided Jacksonian convulsions. Artificial respiration was administered and an intratracheal tube was quickly slipped into the trachea. He began to breathe again and within twenty minutes his condition was fairly good. Roentgenograms of the head were then taken and they revealed a linear fracture in the left frontal bone. He rapidly improved and by the next day was alert and cooperative; he was dismissed from the hospital six days following injury. It was astounding how quickly this patient recovered from near death to a relatively good condition.

TABLE VI
ROENTGENOGRAPHIC AND SPINAL FLUID FINDINGS IN TWENTY-TWO PATIENTS WITH EXTRADURAL HEMATOMA

	Ipsi-lateral	Contra-lateral	Bi-lateral	
Skull fracture				
By x-ray (14 patients x-rayed)	10	1	2	18
By surgery or autopsy	5	..	..	
Pineal shift	..	..	..	2
Spinal fluid (12 patients punctured)				
Pressure				
Above normal	..	..	..	8
Below normal	..	..	..	1
Normal	..	..	..	3
Appearance				
Bloody	..	..	..	8
Clear	..	..	..	2

Several times episodes of a similar nature have been witnessed in young children although usually the picture is somewhat less dramatic. The attending surgeon's judgment is taxed to the utmost to determine whether surgery is indicated. He must not procrastinate too long, and if signs of improvement have not been observed within a short time exploration for extradural or subdural hematoma must be undertaken immediately.

SURGICAL CONSIDERATIONS

Obviously the purpose of surgical treatment is to relieve the pressure on the brain as rapidly as possible by evacuating the hematoma and to employ every feasible measure to prevent a recurrence of the clot. The operation should be carried out not only in a well equipped hospital but also in a hospital where the surgeon can follow the postoperative course of the patient. Fewer patients will be lost by sending the patient to the surgeon rather than by the surgeon going to the patient. A few minutes can mean the difference between life and death, and in my opinion less time will be lost if the surgeon, upon receiving a call regarding a possible extradural hematoma case, will order the operating room in his own hospital set up rather than pack his instruments and go elsewhere to operate.

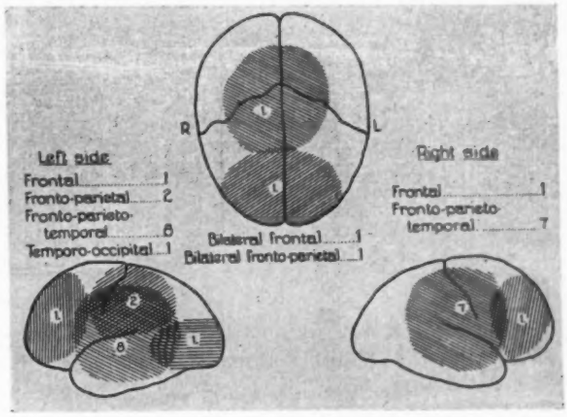
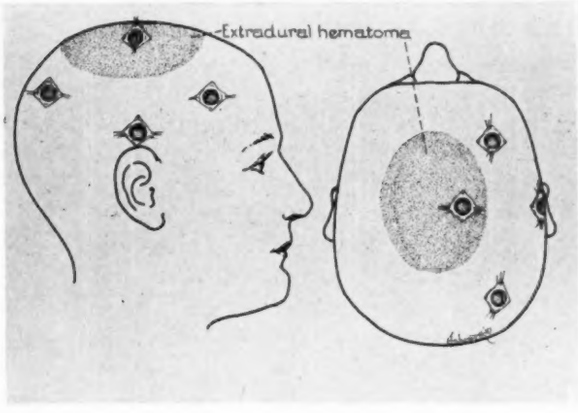


FIG. 1. Location of extradural hematomas in twenty-two patients.



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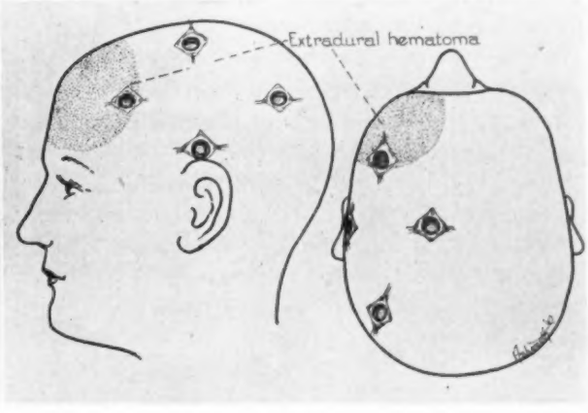

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FIG. 2. H. C., bilateral extradural hematoma located through a burr hole high in the right parietal area.
FIG. 3. J. H. extradural hematoma in the left frontal region.

Site of Hematoma. In order to be evacuated the clot, of course, must first be located. A study of the location of the hematoma in this series of twenty-two cases reveals that there was one left and one right frontal hematoma. (Fig. 1.) The frontoparietal and frontoparieto-temporal hematomas on both sides totaled seventeen. There was one hematoma in the left temporooccipital region. One bilateral frontal hematoma and one bilateral fronto-parietal hematoma were encountered. I cannot agree with the opinion that one burr hole or even two will rule out an extradural hematoma. In this series one burr hole on each side in the usual location would have missed the hematoma in five instances. The following two cases are illustrative:

H. C., an eighteen year old white male, was thrown from a horse. He was instantly stunned but recovered consciousness. By the time he arrived at the hospital, one and one-half hours later, he was becoming restless and soon after admission to the hospital his left leg and left arm became weak. His sensorium became more cloudy. Neurologic consultation was requested, and the patient was operated upon approximately forty-eight hours after injury. The fourth burr hole finally located an extradural hematoma high in the right parietal area. (Fig. 2.) The hematoma was bilateral and had stripped the superior longitudinal sinus away from the bone.

J. H., an eleven year old white male, was knocked from his bicycle. He was dazed but carried on a conversation with his mother a few minutes later. When he entered the hospital, approximately thirty minutes after the accident, he was mentally clear but complained of a headache. After being in the hospital a few hours he became drowsy. Finally surgical consultation was requested, and the patient was operated upon approximately thirty-six hours after injury. A hematoma was found in

the left frontal region, the anterior burr hole being on the posterior edge of the hematoma. (Fig. 3.)

Munro and Maltby[3] state that of twenty patients who died following operation there were three in whom the burr holes failed to reveal the hematoma. In my own series of twenty operative cases the wrong side of the head was first burr-holed in three instances before the hematoma was finally located. I have not employed air encephalography in this group of cases because most of these patients were too ill to tolerate such a procedure. As previously stated eighteen of the twenty-two were comatose upon arrival at the hospital. Therefore, it is my conclusion that the procedure of choice is to place burr holes—as many as four if necessary—on the side of the head where one suspects the hematoma, and if the hematoma is not found burr holes should then be placed on the opposite side of the head.

Bone Flap vs. Subtemporal Decompression. Having located the clot and having reduced the intracranial pressure by sucking out a portion of the clot through the burr hole, the next consideration is what type of procedure will most likely effect a recovery of the patient. In eight of the twenty patients upon whom I have operated the burr hole was converted into a decompression by rongeuring away bone while in twelve patients a bone flap was turned. There were four deaths among the first group of patients and two deaths among the second. I cannot definitely state that the greater number of deaths in the decompression group was the result of the procedure because it is possible that the four patients who died following the decompression type of operation would have died regardless of what procedure was employed. However, I am not in accordance with the opinion that expanding a burr hole into a decompression is the method of choice because it can be done rapidly. Once the major part of the pressure has been relieved the patient will get along just as well on the operating table while he is receiving oxygen and a blood transfusion as he will back in bed. In other words, after the pressure has been relieved there is no particular reason for rushing through the operation. Therefore, the best surgical procedure is the one which gives the best assurance against recurrence of the clot. Recurrence of the clot has, in my hands, been no small problem. To my knowledge the clot has recurred in four of the twenty patients upon whom I operated. Fortunately, the recurrence was recognized and the four patients were re-operated upon and the clots again evacuated. All four subsequently recovered. I strongly suspect that in (R. C. J.) a recurrence of the clot was the cause of death. The patient was operated upon in a hospital 250 miles from Portland and was in good condition when I left him. The next day he became worse and expired three days after surgery. I have never operated for extradural hematoma away from home since that time.

Apparently others have been plagued with the recurrence of hematomas. Reichert and Morrissey[9] report two such cases. In one case the hematoma was evacuated and the wound packed. The packing was removed eighteen hours after operation, and shortly thereafter the patient became restless and stuporous. He was taken back to the operating room and a large amount of extradural blood was again found. Evacuation this time resulted in recovery. In their second case a burr hole located the clot in the left parietal area and 4 or 5 ounces of blood were removed. The burr hole was enlarged and bleeding controlled. Two days after operation the patient again became stuporous. A burr hole in the left occipital region located another large clot. A bone flap was turned in the left parietooccipital area and 4 ounces of blood were removed. The authors do not express an opinion whether this last clot was a recurrence of the original clot found in the left parietal area or whether it was present when they operated the first time but was undiscovered.

McKenzie[2] recognized that a clot may reform and warned, " . . . re-exploration is indicated if one suspects that the clot has reformed." However, a careful examination of the patients in his series revealed that he did not re-operate upon any of his patients for recurrence and that those patients who died apparently did not die from recurrence. Ellis[10] operated upon a patient, performing a right subtemporal decompression and removed a clot 3.7 cm. in diameter. The clot recurred and the patient was re-operated upon, with resulting recovery. Munro and Maltby[3] lost one patient because of failure to recognize a recurrence of the hematoma. Another of their patients had a recurrence which was recognized and operation resulted in recovery.

I have been impressed with the amount of bleeding encountered in most of these cases at the time of operation. I have wondered whether there is some undetectable cause for bleeding which is partially responsible for the formation of the original hematoma. A check of the bleeding and coagulation time in my patients has revealed no abnormalities. Nevertheless, it seems to me that the bleeding from bone and dura is more vigorous than is usually encountered in the ordinary intracranial operation. Several maneuvers have been devised to help control bleeding and therefore prevent recurrence of the hematoma. Ligation of the external carotid artery in the neck, packing of the wound with gauze and opening the dura widely have all been advocated. The results of my own experience in this series of cases indicates to me that a clot can be more thoroughly evacuated, bleeding better controlled and the danger of recurrence lessened by turning a bone flap rather than performing a subtemporal decompression. (Fig. 4.) By means of a bone flap a wide area of the dura which has been stripped away from the undersurface of the bone can be exposed. The middle meningeal artery and any major bleeding vessels can be either clipped with silver clips or ligated with silk sutures. The dura should be pulled snugly against the bone edge by means of sutures placed not more than 1 cm. apart; bits of gelfoam or fibrin foam underneath the bone edge may aid in controlling the bleeding. If the exposed dura continues to bleed, the dura may be opened and the dural flap completely excised, resuturing the dural flap as one would a free graft. If the undersurface of the bone flap continues to bleed, the bone flap may be detached completely, then tied in place, or sutures taken in the dura may be brought out through the bone and skin flap to the outside according to the method of Poppen.[11]

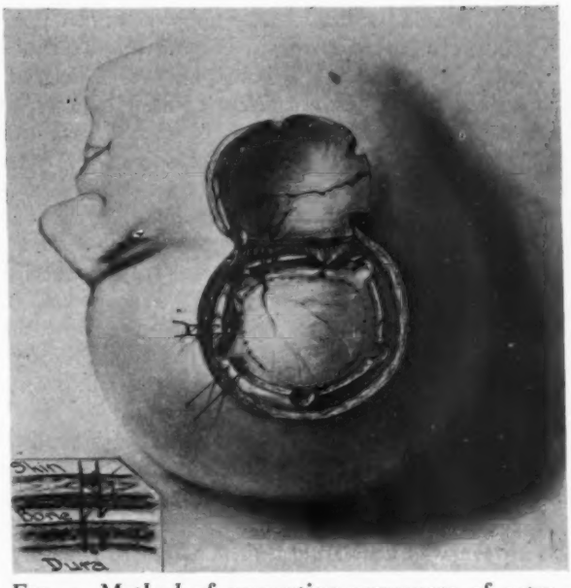

FIG. 4. Method of preventing recurrence of extradural hematoma.

ANALYSIS OF DEATHS

An analysis of the cause of death in the fatal cases reveals that some patients might have recovered if their cases had been handled differently. The fatal cases have been segregated into four categories: (1) erroneous diagnosis; (2) delay in operation; (3) recurrence of the hematoma and (4) concomitant severe brain injury.

Erroneous Diagnosis. In one instance the patient died because the diagnosis of contusion of the brain rather than extradural hematoma was made. (R. R.) was brought to the hospital approximately two hours after he had sustained a head injury. A low cerebrospinal fluid pressure, very bloody spinal fluid and negative Babinskis were the principal points which led me to believe that the patient had a severely contused brain rather than an extradural hematoma. He died seven hours after being admitted to the hospital, no surgery having been performed. Autopsy revealed a huge extradural hematoma.

Delay in Operation. In two cases the delay of the operation was the fault of the attending physician. In another two instances it was failure of relatives to recognize the seriousness of the condition; therefore, these patients were not brought to the hospital until *in extremis.*

J. H. was struck on the head by a sapling and was taken to the hospital in a small town. Apparently the attending physician was not aware of the gravity of his condition. He gradually became worse over the next five days and was finally transferred to Portland *in extremis.* An extradural hematoma was evacuated immediately but the patient failed to improve. Re-exploration was undertaken two days after the first operation but no recurrence of the hematoma was found. The day after the second operation he expired and it was thought that severe, prolonged compression of the brain, even though the hematoma was eventually evacuated, was responsible for his death.

R. O. was admitted to the hospital about noon in relatively good condition. During the afternoon he was observed by the house staff and his condition seemed to remain fairly good. However, at 6 P.M. his respirations suddenly ceased. He was operated upon under artificial respiration. After evacuation of an extradural hematoma he resumed respirations and the intratracheal tube was removed. The patient shortly thereafter vomited a large quantity of material and aspirated the vomitus. He died twelve hours after injury or ten hours after being admitted to the hospital. Had he been operated upon during the afternoon when his condition was better he no doubt would have survived.

J. G. was brought to the hospital eight hours following injury. His condition was relatively good for seven hours after he was hurt. Respirations stopped one-half hour after arrival at the hospital. Operation was undertaken under artificial respiration but he failed to recover, his heart stopping five hours after the operation had been completed.

R. J. was *in extremis* on arrival at the hospital seven hours after injury. The parents had delayed action waiting for the family doctor. Immediate surgery was advised when the patient finally reached the hospital, but he died on the elevator on the way to the operating room.

Recurrence of the Hematoma. As previously stated recurrence of the hematoma may have accounted for one of the deaths. The patient was operated upon in a small town, and his condition was good at the conclusion of the operation; however, he died three days later without re-exploration. No autopsy was obtained.

Concomitant Severe Brain Injury. Concomitant severe brain damage was responsible for two deaths. B. O. was in very poor condition on arrival at the hospital four hours after injury. He was operated upon immediately and the hematoma evacuated but he failed to improve. He died twelve hours following operation. While autopsy showed no recurrence of the extradural hematoma, he had intracerebral hemorrhages, particularly in the pons.

The intrapontine hemorrhage may have been the result of the original injury to the head or it could have been the result of severe, prolonged compression of the brain. Intrapontine hemorrhages are not infrequently seen in patients with severe brain compression such as those suffering from intracranial tumors.

A. K. was in poor condition when he arrived at the hospital. Surgery was performed six hours after his arrival. The brain was badly lacerated and an extradural hematoma was present. Evacuation of the hematoma failed to cause improvement in the patient's condition and he died approximately six hours after surgery.

CONCLUSIONS

1. The twenty-two extradural hematoma cases herein reported constituted 1 to 2 per cent of acute head injury cases.

2. Twenty of the twenty-two patients in this series were operated upon and six of the twenty died (30.0 per cent mortality). Two additional postmortem cases are included in the series (36.4 per cent mortality for the twenty-two cases).

3. The middle meningeal artery or one of its branches was the most frequent source of bleeding but tear of a venous sinus or emissary vein accounted for a few of the hematomas in this series.

4. A history of a lucid interval was the most constant diagnostic point in cases of extradural hematoma.

5. Hemiparesis was a more constant localizing sign than changes in tendon or superficial reflexes. The Babinski reflex was more often bilaterally positive than unilaterally positive and therefore was frequently of no localizing value.

6. An ipsilateral dilated and/or fixed pupil was recorded as being present in eight (36.4 per cent) of the twenty-two patients. A dilated and/or fixed pupil occurred one-fourth as frequently on the contralateral side as on the ipsilateral side.

7. Skull fracture was recorded as being present in eighteen patients (81.8 per cent) and was usually on the ipsilateral side although in one instance it was contralateral to the hematoma.

8. The spinal fluid pressure was usually elevated but was normal or subnormal in some cases.

9. Surgical evacuation of the hematoma must be undertaken with all speed in a well equipped operating room and in a hospital where the surgeon can follow the patient postoperatively. The patient must be brought to the surgeon—not the surgeon to the patient. One must be on constant guard against a recurrence of the hematoma.

10. One burr hole on each side of the skull is not enough to rule out extradural hematoma.

11. A bone flap is usually a more satisfactory operation than evacuation of the hematoma through an enlarged burr hole.

12. In the series of twenty-two cases herein reported had all attending physicians been alert and acted promptly, four of the eight deaths might have been averted. Prompt action by relatives would conceivably have saved another two, thus reducing the deaths from eight to two which seem to have been inevitable because of concomitant brain injury.

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DISCUSSION

Elisha Stephens Gurdjian (Detroit, Mich.): Dr. Raaf stated that most extradural hematomas are due to a rupture of the middle meningeal vessels. It is rather important to point out that the bleeding in most of these cases is both venous and arterial, but more venous than arterial, and the middle meningeal groove actually is caused by three or four veins that accompany the middle meningeal artery along the lateral aspect of the skull.

The mechanism of extradural hematoma of middle meningeal origin, unassociated with fracture of the skull, is interesting. It can occur. Extradural hemorrhage, particularly in the frontal region, may occur unassociated with a fracture of the skull. This was experimentally shown by Sir Percival Pott more than one hundred years ago when with the use of a flat wooden mallet he was able to cause deformations of the skull unassociated with fracture, resulting in tearing off of the dural lining from the skull with beginning bleeding in the extradural region. Such bleeding can cause dissection of the dura off the skull, with more bleeding from the small veins of the dura which connect with the skull. This may eventuate in a huge clot formation, particularly in the frontal region.

The lucid interval has been less common in our series. If the patient has a severe head injury, such as in a deceleration impact in an automobile accident, the concussive effect of the blow may not permit the patient to recover from the initial unconsciousness and the patient may then lapse into the unconsciousness caused by the extradural hematoma and for all intents and purposes he may remain unconscious throughout.

In such cases, therefore, the most significant observation is increasing drowsiness or increasing unconsciousness and increasing inability to react to stimuli such as pinching, pin prick, etc.

If patients develop the hematoma from blows such as falling off a bicycle—and by the way, many instances of extradural hematoma result from bicycle-automobile accidents—then the chances for a lucid interval are good in such cases. The focal signs, as Dr. Raaf brought out, are quite positive in these cases and the most typical syndrome is a dilated pupil on the ipsilateral side, with weakness or paralysis of the opposite half of the body. This is obtained frequently when the hematoma is in the frontotemporoparietal region. With the hematoma elsewhere or high up over the interparietal area, the patient usually has equal pupils or constricted pupils and the dilated pupil on the side of the lesion described by Hutchinson is not seen.

Dr. Raaf's idea about making multiple exploratory holes is a good one since there is always a chance that one may miss these hematomas in other than the usual places and multiple trephine openings may help locate such lesions.

Spinal puncture on these patients usually reveals bloody fluid. If the spinal fluid is bloody, this does not rule out middle meningeal hemorrhage. In other words, then, just because the patient has a bloody spinal fluid to say that he is suffering from contusions and bruises of the brain would be a bad mistake in cases complicated with extradural hematoma. All of the patients that we

have punctured have had bloody spinal fluid even though the hemorrhage was mainly in the epidural space.

Finally, a word on the question of operative treatment of these patients, subtemporal decompression versus the bone flap. If the hemorrhage is in the frontotemporoparietal area, subtemporal decompression works quite well since most of the hemorrhage is under the temporal muscle. I would say we have done about 75 per cent subtemporal decompressions and 25 per cent bone flaps. If, on the other hand, the hemorrhage is in areas other than the subtemporal region, such as over the vertex and the frontal region, obviously a small bone flap would be preferable.

HARRY E. MOCK (Chicago, Ill.): Many writers in the past have stated that extradural hemorrhages seldom occur in children. The explanation given for this is the intimate attachment of the dura to the skull bones in childhood. This probably accounts for the fact that some of the worst compound fractures we have seen have occurred in children with the dura badly torn and with blood, cerebrospinal fluid and macerated brain escaping. Nevertheless, extradural hemorrhages do occur in childhood and far more frequently than we have been led to believe. Of 18 patients with extradural hemorrhages operated upon by us five were children. Four of them had small linear skull fractures and one had a simple depressed fracture. All five of these cases occurred in communities from 25 to 125 miles from Chicago. All of them were in serious condition when we were called in consultation. As soon as the diagnosis was made the operation was performed in the local hospital. In our opinion moving them back to our hospital in Chicago would have jeopardized their lives. Dr. Raaf and I differed on this point last year but I still believe the "surgeon must go to the skull fracture case, not the skull fracture to the surgeon." There are exceptions, of course, but this is a good rule in the majority of serious brain injury cases. If we break the rule, then the consultant, after seeing the patient, should be the one to break it. Four of these children recovered, the one with the depressed fracture died.

This case of a depressed fracture with an extradural hemorrhage raises another important point that needs emphasizing. Most of us have taught that the depressed skull fracture is not an emergency. It can wait several days or until the patient's condition has improved before operation need be performed. One of my father's students became an assistant to a good general man near Chicago. Shortly thereafter a six year old boy was admitted to their service in the local hospital, with a depressed skull fracture. He was unconscious but not in a grave condition. This ex-student who first saw the patient refused to have the child x-rayed at once, which was right. The next day the child was worse and the senior doctor insisted on an x-ray which revealed a depressed fracture in the right parietal region. He thought an operation should be undertaken. The ex-student quoted my father as strongly advising delayed operation for such depressed fractures. At the end of the third day following injury my father was called in consultation. The child was in an extremely serious condition with the focal signs disguised by a deep coma. Operation was indicated but it was probably too late to be of benefit. At operation a fair sized extradural hemorrhage was found nestled beneath the simple depression.

Dogmatic teaching such as this is dangerous and undoubtedly cost this child his life. Great emphasis should be placed upon the possibility of an extradural hemorrhage lying beneath every depressed skull fracture. At the first evidence of focal signs immediate rather than delayed operation is necessary.

During the last year Dad, Charles J. Mock and I have become interested in intracranial injuries in football players. We found that the American Football Coaches' Association had records of deaths among sand lot, high school and college football players since 1931. During the sixteen years until 1947 there we e 307 deaths directly due to football and 46.3 per cent of these were due to brain injuries—usually signed out as "cerebral hemorrhages." During the 1947 season twenty-four football players were killed and twelve of these (50 per cent) died from intracranial injuries.

We have contacted the authorities in these schools and through them have corresponded with the doctor, hospital or coroner responsible for each of these twelve patients. Two of them had extradural hemorrhages and one a subdural which were found at operation before death. The remaining nine cases were all signed out as "cerebral hemorrhage" deaths. Only two of these twelve had autopsies. Coroners are very loath to perform autopsies especially in our smaller communities and especially on a boy who, through the nature of his death, has become a local hero. How many of the 150 "cerebral hemorrhage deaths" in football players since 1931 were really extradural hemorrhages?

Laws should be enforced requiring an autopsy on every skull fracture–brain injury death. Only in this way will we learn how many of these extradural and subdural hemorrhages are being overlooked and the patients allowed to die without benefit of surgery. Skull fractures and cerebral hemorrhages should be considered general terms not acceptable as the cause of death without a careful description of the specific intracranial lesion or lesions.

JOHN E. RAAF (closing): I certainly agree that extradural hemorrhage does occur in childhood. I do not have in mind just how many of our twenty-two patients were children, but I can recall at least five in our series.

Dr. Mock, Sr. and I have been arguing for several years regarding the question of whether the surgeon should go to the patient or the patient to the surgeon. Apparently at the present time there is still no meeting of the minds but we have lots of fun arguing.

I agree that depressed skull fracture is not a surgical emergency unless it is a compound depressed skull fracture. In my experience most of the extradural hematomas have occurred underneath linear fractures rather than underneath depressed skull fractures, and an extradural hematoma, in my opinion, is certainly a grave surgical emergency. I have seen patients with extradural hematomas die within five or six hours of the time of injury.

RESTORATION AND PRESERVATION OF ARTERIAL CONTINUITY FOLLOWING TRAUMA

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New York, New York

DURING the past five years interest among surgeons has been focused on methods to maintain arterial continuity in the treatment of injuries to an artery of an acute and chronic nature. Matas,[1] Blakemore,[2] Freeman,[3] Shumacker,[4] Herrmann[5] and Wise[6] have emphasized the importance of preservation of the main arterial flow as the ideal in the management of acute arterial injuries as well as traumatic arterial aneurysms and arteriovenous fistulas.

Reid,[7] Holman[8] and Elkin[9] by their excellent experimental and clinical studies have shown that quadruple ligation and excision of a traumatic arteriovenous fistula is followed by improvement in the circulatory dynamics and cure of the fistula. However, relative vascular insufficiency of an extremity which limits full exercise tolerance following interruption of arterial continuity has been clearly demonstrated by Blakemore.[2] For that reason the ideal cure of the fistula and maintenance of continuity of the artery have been sought by a number of surgeons and achieved with considerable success.[2,3,4]

During World War II many efforts were made to restore continuity of an artery following an acute injury and certain obstacles were encountered which made this aim difficult to achieve regardless of the technical method employed.[10,11] The time factor between the occurrence of injury and adequate operative facilities was frequently twelve to seventy-two hours and this alone was responsible for failure of many arterial anastomoses to function. Secondly, a large percentage of the casualties sustained multiple severe injuries associated with shock which precluded the time-consuming operation of arterial anastomosis. However, in civilian practice acute trauma to an artery may occur during the course of an operation such as periarterial sympathectomy, hernioplasty, varicose veins, etc. Further, patients having arterial trauma resulting from stab and gunshot wounds and compound fractures are usually admitted to the hospital within one to four hours after injury and can be cared for promptly and effectively. With proper vascular equipment and personnel trained in arterial anastomosis many of these arteries can have their continuity restored with resulting salvage of a greater number of useful extremities.

ACUTE ARTERIAL INJURIES

In the management of acute arterial injuries certain points must be considered which are essential for the success of an anastomosis: First, attention to details which will lessen the possibility of infection: (1) adequate and thorough débridement in a contaminated wound; (2) skin exclusion by towels and Michel clips; (3) administration of large doses of penicillin. The second important factor has to do with the technic of anastomosis. If there has been loss of arterial substance, a vein graft should be employed rather than the suturing of the ends of the artery under longitudinal tension. Further, if a vein graft is joined by means of the non-suture Vitallium tube technic, certain details of the method should be observed. (Fig. 1.) On the other hand, if the vein graft is sutured to the ends of the artery, careful technic is imperative not to injure the intimas of the artery or vein. Either the Carrel method or the continuous mattress suture technic may be employed for secure anastomosis.[12] The third important factor is the use of anticoagulant therapy postoperatively to aid in the prevention of thrombosis. Heparin is injected intravenously immediately at the completion of the anastomosis and continued postoperatively either by the intermittent intravenous or subcutaneous route until dicumarol effect is evident by determination of the prothrombin time. Anticoagulant therapy should be maintained for seventeen to twenty-one days. The fourth important factor is the elimination of arterial spasm by means of the judicious use of any one or combinations of

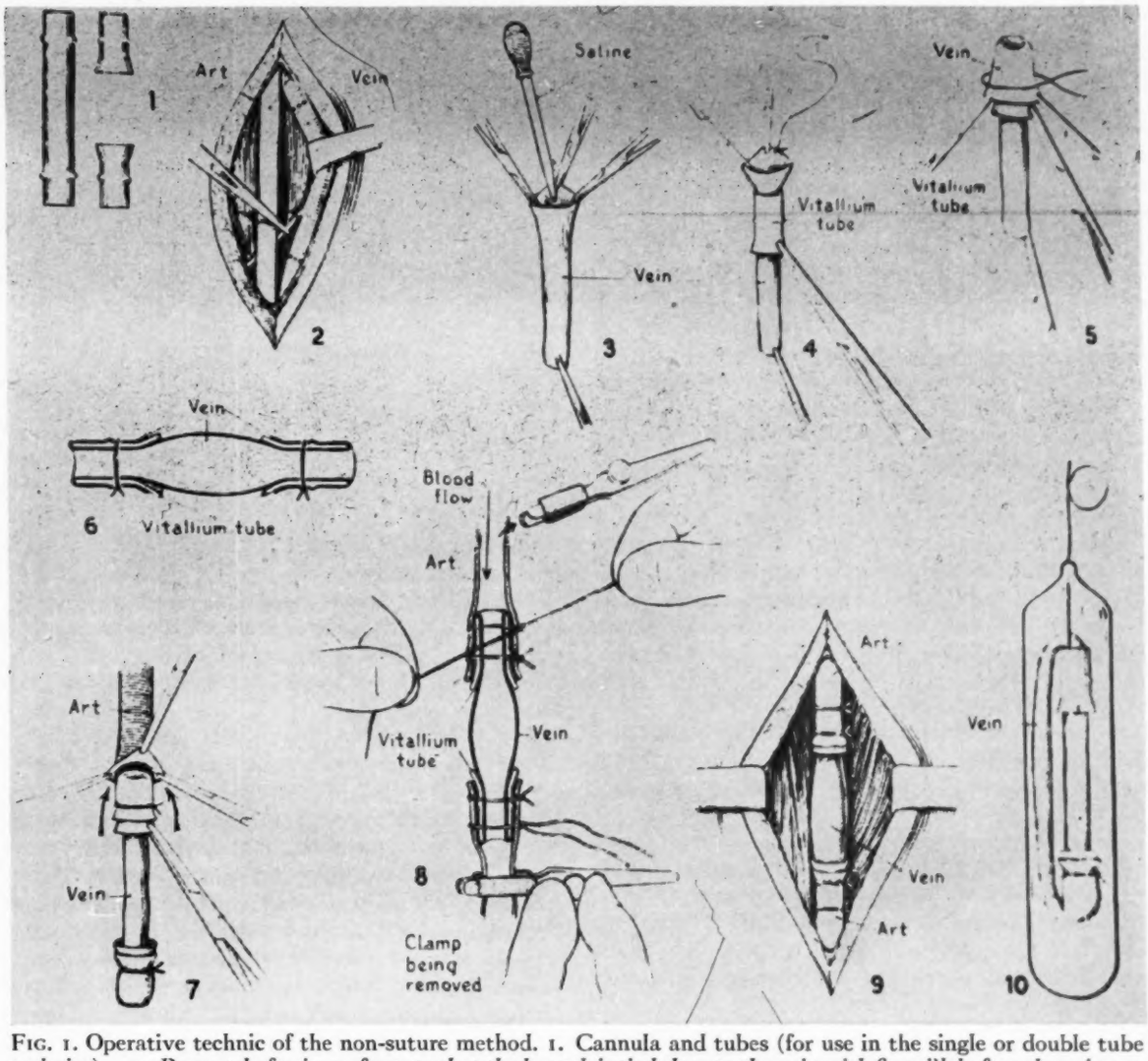

FIG. 1. Operative technic of the non-suture method. 1. Cannula and tubes (for use in the single or double tube technics). 2. Removal of vein graft; note that the branch is tied close to the vein with fine silk before clamping. 3. Irrigation of vein graft with isotonic solution of sodium chloride to which a small amount of heparin may be added if desired. 4. Method of triangulating end of vein with mosquito clamps. 5. Cuffing and securing everted end of vein on the Vitallium tube. 6. Double tube technic with the vein graft mounted. 7. Introducing the distal end of the vein graft mounted on a Vitallium tube into the proximal end of the artery. 8. Tying fine silk ligatures just snug enough to prevent blood from penetrating between the vein and artery intimas. Also releasing the proximal rubber shod clamp first to facilitate the passage distalward of any residual air bubbles within the graft. 9. Completed anastomosis; the perivascular tissues are closed snugly around the anastomosed artery when possible. 10. A convenient way of preserving, hermetically sealed in an ordinary test tube, a vein graft for quick freezing. The graft is moistened with isotonic solution of sodium chloride, one end mounted on a Vitallium tube in the usual manner and the other end is passed through a second tube and brought over the first tube to protect the intima until used. A wire serves to suspend the graft.

the following: papaverine, tetraethylammonium chloride, paravertebral procain block and sympathectomy.

To illustrate the principles discussed above we would like to cite two cases of acute arterial trauma in which arterial anastomosis was attempted but resulted in failure:

A twenty-eight year old man sustained a posterior dislocation of the knee joint in an automobile accident and was admitted to City Hospital where it was evident that the popliteal artery had been severed. He was operated upon within five hours of his injury, the dislocation reduced and the popliteal artery which had been completely divided was sutured under great longitudinal tension. Twenty-four hours later evidence of gangrene developed because of inadequacy of the anastomosis and amputation was performed.

The second case was a fifty-eight year old white man who sustained an injury in the course of an operation on his saphenous vein. The artery was clamped but prior to division was identified. On removal of the clamp bleeding ensued necessitating reclamping. Following removal of the crushed part of the artery, end-to-end anastomosis was effected under considerable longitudinal tension. Pulsations of the popliteal and dorsalis pedal arteries were easily palpated and oscillometric readings were equal in both legs. The patient was treated with penicillin and papaverine and had an uneventful postoperative course until the thirteenth day when sudden hemorrhage occurred requiring exploration of the wound and ligation of the separated ends of the artery. Wound infection was evident only in the deeper parts by the collection of pus around the artery. Failure to prevent infection and longitudinal tension in the anastomosis were the two factors which led to this unsuccessful attempt to maintain continuity. Although gangrene did not occur subsequently, the patient has had marked evidence of arterial insufficiency.

The following two patients operated upon by Blakemore[2] illustrate a satisfactory method of management of acute arterial injuries resulting from falls through a plate glass door or window:

M. E., a seven year old boy, was admitted to the Presbyterian Hospital July 20, 1943, in shock due to hemorrhage from a severed brachial artery. The boy's left arm had been pushed through a glass door while at play. He received an irregular laceration across the inner aspect of the middle section of the arm. The brachial artery, median and ulnar nerves were severed. The patient was promptly given 500 cc. of blood, 300 cc. of isotonic solution of sodium chloride and 2 Gm. of sodium sulfadiazine intravenously.

Five hours after injury a pneumatic tourniquet was applied well above the wound under ether anesthesia. The skin was carefully prepared and the wound thoroughly irrigated with saline. The retracted ends of the severed brachial artery were freed for a distance of 5 to 6 cm. The tourniquet was released sufficiently to flush out severed vessels. Rubber shod clamps were applied to the ends of the severed artery and the latter irrigated with saline. The cut ends of the brachial vein were transfixed with C Deknatel silk. As débridement proceeded, the smaller vessels were ligated with B Deknatel silk. At this point of the operation the team divided. This enabled one section to proceed with repair of the nerves, using arterial silk, while the other proceeded with preparation of a vein graft for bridging the arterial defect. Accordingly, the left superficial femoral vein was isolated for a distance of 10 cm. distal to the origin of the profunda. Branches were ligated with B. Deknatel silk flush with the vein, clamped, cut and ligated distally. A ligature of No. 1 Deknatel silk was placed on the distal end of the femoral vein. The blood was milked upward and another ligature placed proximalward. The vein was further secured with transfixion ligatures and the intervening segment removed. The vein graft was thoroughly irrigated with saline. A silk suture on a straight needle passed through the wall of the distal end served to pull the vein through a 2 mm. Vitallium tube and later, when cut short, to identify the distal end of the vein graft. The end of the vein was everted (cuffed) over the Vitallium tube and held in place by a ligature of No. 1 Deknatel silk placed behind a tying (holding) ridge. The other end of the vein graft was mounted in identical manner on a second 2 mm. Vitallium tube. (Care must be taken to avoid a valve at the eversion site to prevent diaphragm occlusion.)

Next, the severed ends of the artery were débrided and again irrigated to remove clinging particles of fibrin. (Control of blood flow by the rubber shod clamps placed well away from the ends must be absolute.)

The distal end of the severed artery was then triangulated by placing mosquito clamps, taking 1.5 mm. bites on the cut edge. The flange of the Vitallium tube carrying the proximal end of the vein graft was grasped with a stout, straight clamp and the graft was dipped in saline. Following this, the vein covered tube was introduced into the funneled end of the artery and the latter brought well up on the tube. The artery was secured to the tube, intima to intima with the vein, by a No. 3 Deknatel ligature tied tightly behind the holding ridge, using a surgeon's knot. The second Vitallium tube bearing the distal end of the vein graft was irrigated with saline (using a blunt-nosed medicine dropper) and introduced into the proximal end of the artery in an identical manner. Finally, ligatures of No. 1 Deknatel silk were placed around the artery, barely snugging the artery to the cuffed vein at a point 1 to 1.5 mm. from the ends of the Vitallium tubes.

Just before removing the rubber shod clamps, 15 mg. of heparin (1.5 cc. of liquaemin) were injected into the artery proximal to the anastomosis, using a hypodermic needle. The proximal clamp was removed first, followed immediately by removal of the distal rubber shod clamp.

A pink color of the boy's hand resulted immediately after re-establishment of blood flow and only a few minutes elapsed before the left hand was as warm as the right. The muscles, fascia and skin were approximated with fine silk. The patient received 300 cc. of blood during the operation and left the table in excellent condition. The arm

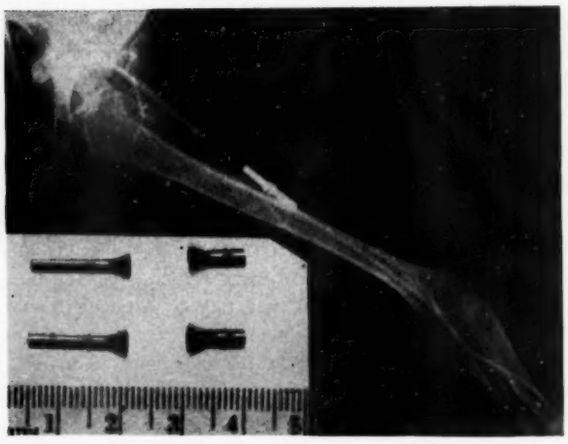

FIG. 2. Arteriogram of the anastomosed brachial artery in the first case one month after operation. Whereas the funneled ends of the Vitallium tubes are close together, a column of diodrast may be noted passing through the intervening vein graft. Compare the long tubes as used in this case with the shorter tubes of recent design shown in the inset.

was placed in a plaster splint with the hand in volar flexion.

Postoperatively the wound healed per primam. The patient was discharged on the eleventh postoperative day in a constant tension splint to permit exercise of unopposed extensor muscles but to protect the paralyzed flexor muscles of the forearm against overstretching. Sulfadiazine therapy was continued through the fifth postoperative day. Daily observation of the left radial pulse revealed it unchanged in volume.

Follow-up one month later showed that the patient was receiving physiotherapy. The left radial pulse remained good. An arteriogram (Fig. 2) confirmed the patency of the anastomosis. However, thrombosis of the anastomosis took place immediately following the injection of diodrast. Five months later chronaxia studies revealed innervation of the forearm muscles supplied by the median nerve. At examination fourteen months later there was complete sensory and motor recovery of the median and ulnar nerves. However, there was some inability to extend the fingers completely due to weakness of the interosseus muscles, although chronaxia studies revealed complete regeneration. Seventeen months later there was complete return of function.

R. J., a fifteen year old colored boy, entered the Presbyterian Hospital July 7, 1944, with a severe laceration of his left arm. He incurred the injury falling through a plate glass cellar window. A tourniquet was promptly applied. After his arrival at the hospital some hours later a pneumatic tourniquet was applied and deflated at one-half hour intervals. Family and past history was non-contributory.

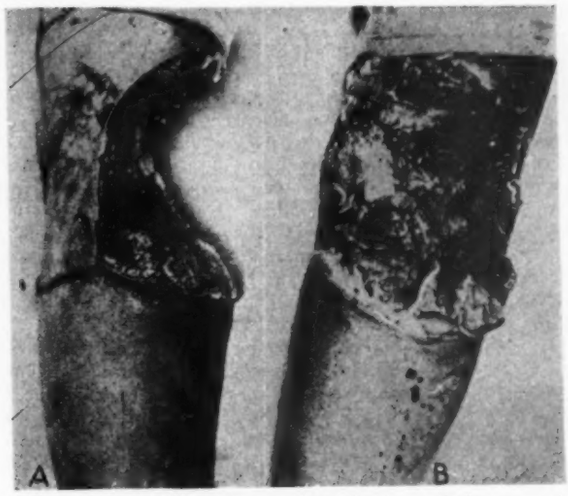

FIG. 3. Lateral (A) and anterior (B) views of the wound in the second case.

Physical examination revealed the temperature to be 101°F., pulse 132, blood pressure 160/80. He was an apprehensive, well developed boy, not in shock. Examination of the left arm revealed a transverse laceration starting in the mid-biceps region, directed obliquely downward, dividing all soft parts to the bone and entering the elbow joints anteriorly. The laceration involved approximately two-thirds of the circumference of the arm. The radial and median nerves were severed as were the brachial artery and accompanying veins. As a result of muscle retraction the wound gaped widely. The forearm and hand remained cold, pale and pulseless following release of the tourniquet. (Fig. 3A and B.)

The operation consisted of irrigation and débridement of the wound, with suture of the radial and median nerves. The brachial artery defect was bridged with a segment of saphenous vein using the non-suture technic with a 4 mm. Vitallium tube on each end. Twenty mg. of heparin (2 cc. of liquaemin) were given intra-arterially on establishing blood flow through the anatomosis; 5 mg. of sodium sulfadiazine were given in saline during the operation. Hemostasis was completed and the muscles, fascia and skin were sutured. Silk technic was used throughout. The arm was placed in a posterior molded plaster splint with the elbow at right angles. An excellent radial pulse was felt on releasing the brachial artery to blood flow. The wound healed per primam. The radial pulse remained excellent and thirty-four days postoperatively an arteriogram confirmed the patency of the anastomosis. (Fig. 4.)

Follow-up examination at four months showed the radial pulse to be excellent. Chronaxia studies revealed the innervation of the forearm muscles. Muscles supplied by the tourniquet damaged ulnar nerve responded to direct stimulation, whereas there was no response from those supplied

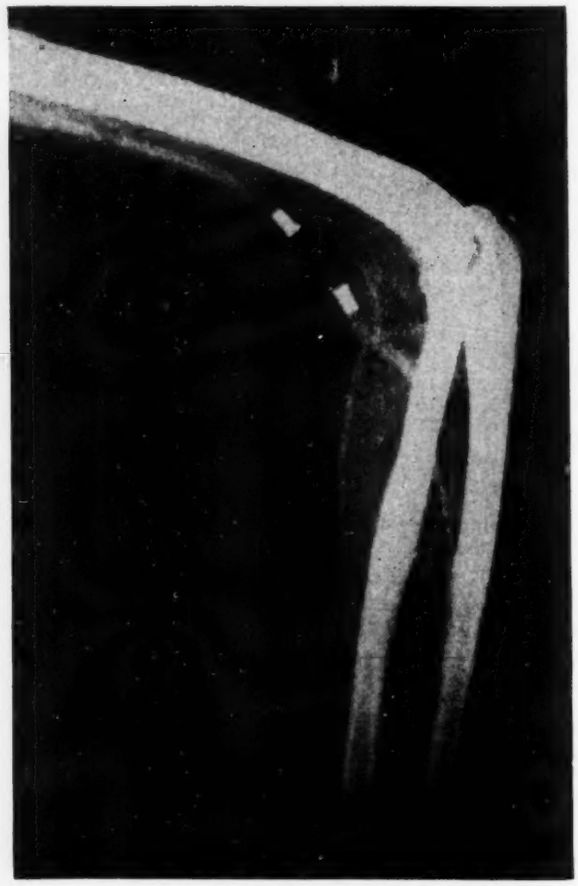

Fig. 4. Arteriogram in the second case thirty-four days after operation. The patent saphenous vein graft is about the same size as the anastomosed brachial artery. The slight bulge of the upper end of the graft marks a valve site in the vein graft.

by the sutured radial and median nerves. Furthermore, the latter muscles were more wasted and fibrotic. Seven months later there was beginning nerve regeneration below the elbow; the radial pulses remained equal.

Holzer[13] recently reported two remarkable cases of acute traumatic lacerations of the abdominal aorta in which continuity was maintained by suture in one and an unlined Vitallium tube in the other.

There are other types of acute traumatic arterial emergencies than the severed artery. For example, contusion of an artery may be followed by thrombosis with its potentially disasterous effect. Proper treatment, however, may be effective in preventing such an unfortunate outcome. The following case is illustrative:

A seventy year old woman fell and sustained a subglenoid dislocation of her left humerus. Examination revealed absence of pulsation of the brachial and radial arteries and no blood pressure or oscillometric readings were obtainable in the involved arm. Under pentothal anesthesia the dislocation was successfully reduced. However, pulse, blood pressure and oscillometric readings remained absent for two hours when following an intravenous injection of procaine the blood pressure was recorded at 120/100 in contrast to 190/110 in the right arm. An oscillometric reading of 1.0 was noted in the left forearm whereas 2.5 was obtained in the right forearm. The patient was started on heparin, 30 mg. every three hours subcutaneously, and 300 mg. of dicumarol were administered by mouth. Forty-eight hours after injury a feeble brachial pulse could be palpated but the radial pulse remained absent for seven days, then gradually returned to normal by the fourteenth day. The blood pressure levels had equalized in the two arms on that day. The exact extent of the injury to the axillary artery in this case cannot be ascertained but it would seem that spasm was present early and persisted because of contusion of the wall of the artery. Although the final outcome may have been as satisfactory without specific treatment, we believe that the use of anticoagulant therapy for several days was useful in guarding against secondary thrombosis. Measures designed to counteract spasm were employed in the form of intravenous procaine and papaverine.

An example of impairment of arterial circulation by pressure and its adequate treatment is shown by the following case:

A nine year old boy fell while playing in the street and sustained a supracondylar fracture of the right humerus. Closed reduction was attempted under anesthesia but was unsuccessful. The manipulation resulted in a progressively enlarging hematoma which caused a gradual obliteration of the radial pulse. Twenty-four hours later the subfascial hematoma was evacuated by incision with immediate return of the radial pulse. Uneventful convalescence followed reduction of the fracture.

In a few carefully selected patients secondary restoration of the continuity of an artery at some period after the primary injury may be worth while. When a major artery has been ligated and the extremity has survived, circumstances may subsequently develop which would necessitate secondary re-establishment of arterial continuity if gangrene is to be averted. It is to be clearly understood that all conservative measures to promote the development of collateral circulation have been employed including sympathectomy. In spite

of the best efforts to augment the collateral circulation some of these extremities go on to impending and occasionally frank gangrene. It would be in this small group that exploration of the region of the divided artery for the purpose of re-establishment of blood flow by means of a vein graft may be efficacious. The following case is illustrative:

A fifty-eight year old white man sustained an injury to his right common femoral artery in the course of an inguinal hernioplasty. The artery was ligated and during the immediate postoperative period the extremity remained viable. In spite of the usual measures to promote collateral circulation, including paravertebral procaine blocks, beginning gangrene of the second toe developed by the seventh postoperative week. Exploration of the common femoral artery revealed fibrosis in juxtaposition to the points of ligature over a distance of 3 cm., with patency of the artery proximally and distally. Technical difficulties due to inadequate armamentarium resulted in a poor anastomosis of the vein graft to the ends of the artery which led to thrombosis on the first postoperative day in spite of anticoagulant therapy. It is our belief that the findings at operation in this case were entirely compatible with a successful restoration of arterial continuity.

Blakemore,[2] Freeman[3] and Shumacker[4] have emphasized the importance of maintaining arterial continuity in the management of arteriovenous fistulas. The following two cases illustrate its application:

A sixty-three year old colored male was admitted to Bellevue Hospital in cardiac decompensation. An arteriovenous fistula was discovered between the femoral artery and vein. It had apparently resulted from an incision and drainage of a suppurative inguinal adenitis thirty years previously. Following measures to improve cardiac function the fistula was excised, the femoral vein ligated above and below the fistula and arterial continuity restored by means of a vein graft taken from the superficial femoral vein and joined to the ends of the artery by the Carrel suture technic. Postoperative convalescence was uneventful and pulsations and oscillometric data in the extremity were entirely normal (preoperative 1.5, postoperative—one week—3.0). The patient has full functional tolerance of the left leg.

A forty-four year old white, construction worker developed a fistula between the right common femoral artery and vein as a result of a dynamite explosion thirteen years before admission to the Horton Hospital, Middletown, N.Y. At operation the fistula was isolated and the artery clamped with rubber-shod clamps above and below. The fistula was then ligated and transfixed maintaining continuity of the common femoral vein. The arterial end of the fistula was divided flush with the artery and the defect closed with a continuous everting mattress suture of No. ooooo silk. A

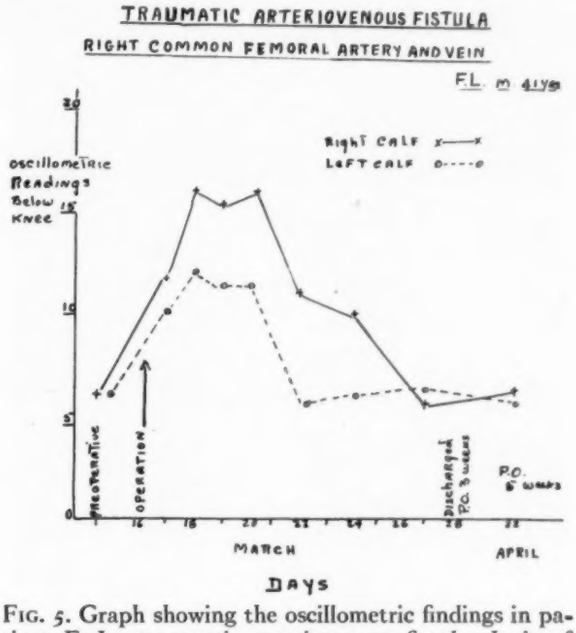

FIG. 5. Graph showing the oscillometric findings in patient F. L., traumatic arteriovenous fistula. It is of interest to note that the right calf (operated side) shows a greatly increased oscillometric swing during the early postoperative period.

3 mm. branch of the artery was also divided at the same time and it was similarly sutured. Following release of the rubber-shod clamps, arterial flow was satisfactory. The wound was closed in layers. One hour postoperatively evidence of serious arterial hemorrhage was noted. The wound was explored and the site of the small branch of the common femoral artery was found to be open. It was again closed with two interrupted mattress sutures of arterial silk. Convalescence thereafter was entirely uneventful and Figure 5 shows the oscillometric readings pre- and postoperatively. The patient has normal exercise tolerance in the right leg.

Matas[1] has repeatedly pointed out the desirability, when possible, of carrying out restorative endo-aneurysmorrhapy, and more recently Blakemore[14,15] has reported on the vein graft Vitallium tube inlay method of treating peripheral arterial aneurysm. The technic is illustrated in Figure 6.

The first patient operated upon by this technic was a forty-two year old negro barber who was known to have had a positive Wassermann reaction

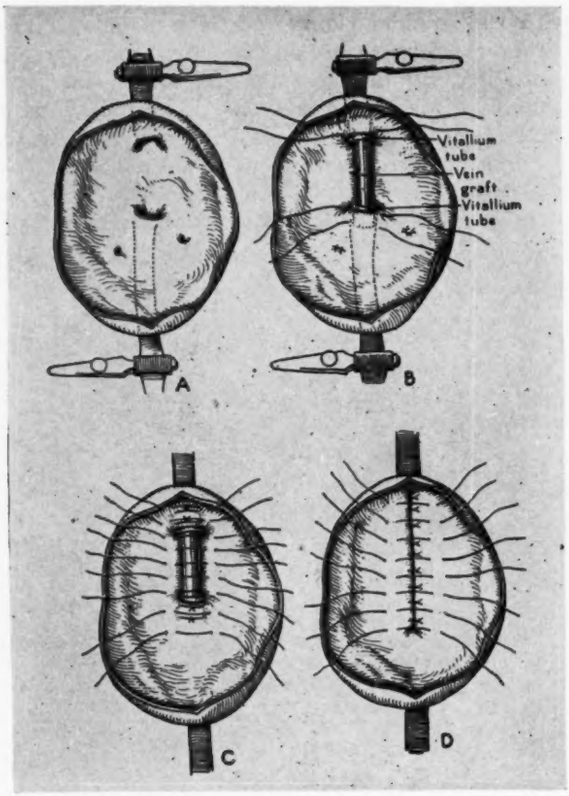

FIG. 6. The technic of intrasacular repair of an aneurysm with vein graft inlay for the maintenance of arterial blood flow.

for seventeen years before admission to the Presbyterian Hospital on May 29, 1947. Antiluetic therapy had been carried out most of the time until three years before the present illness. The patient's Wassermann reaction became negative in 1937 and had remained so. The present illness started two and one-half years before with swelling of the right thigh. Two and one-half years before this the patient was shot through the thigh, the bullet passing through this same area, and the patient thinks some swelling persisted following the bullet injury. During the year before admission growth of the aneurysm had been quite rapid.

Physical examination revealed a well developed and well nourished man who looked older than his stated age. The pupils were regular and active to light and accommodation. The heart was not enlarged; sounds were normal; blood pressure, right arm 145/105. Lungs were clear to percussion and auscillation. The abdomen was normal except for the presence of a right inguinal hernia. A pulsating mass the size of a large grapefruit presented in the right thigh in the lower Hunter's canal region. The right dorsalis pedis pulse was barely palpable.

A diagnosis of arterial aneurysm of the femoral artery was made.

FIG. 7. Arteriogram made eleven days after the procedure shown in Figure 6. Note patency of vein graft inlay although the latter is slightly redundant.

On May 31, 1945, endo-aneurysmorrhaphy with vein graft inlay was performed. Figures 6A to D are drawings of the aneurysm revealing the technical stages. The vein graft was taken from the left superficial femoral vein and mounted on two 5 mm. Vitallium tubes in the usual manner.

Convalescence was uneventful with healing of the wound per primam. The pulse in the vessels of the right foot remained better than before operation but not quite as good as those in the left foot. (Fig. 7.)

Follow-up two months later revealed that the patient had been working continuously on his feet as a barber without swelling of the leg. The site of the aneurysm was scarcely noticeable. Pulsation in the artery distal to the aneurysm remained unchanged.

The above methods of Matas and Blakemore may also find application in arteriosclerotic, mycotic and traumatic aneurysms.

Comment. There are two points which should be emphasized in the management of arterial injuries. First, it is of the greatest importance to have adequate equipment for vascular surgery. This includes: (1) two small Blakemore-Crump clamps; (2) two rubber-shod Bainbridge clamps; (3) two rubber-shod bull dog clamps; (4) one large Blalock clamp; (5) one set Vitallium tubes 3 mm. to 10 mm.; (6) Deknatel No. 00000 braided silk with

atraumatic needle; (7) vaseline or mineral oil and (8) plastic needle holder.

The second important point is to avoid the sacrifice of any arterial collateral vessel. A double turn of a heavy silk suture will usually suffice to control bleeding without injury to the branch or permanent occlusion.

CONCLUSIONS

1. Restoration of arterial continuity in the management of acute and chronic arterial injuries and lesions is a highly desirable objective for the preservation of extremities and full functional activity.

2. Arterial continuity should be restored when possible in the following: (1) acute arterial injuries; (2) repair of arteriovenous fistulas; (3) in the management of aneurysms whether on an arteriosclerotic, luetic, mycotic or traumatic basis and (4) in selected cases of arterial injuries in which ligation was practiced as the initial treatment.

3. We are in agreement with Shumacker[4] that the greater the surgeon's interest in restoration of arterial continuity, the more often will successful arterial anastomoses result.

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MANAGEMENT OF VENOUS THROMBOSIS AND PULMONARY EMBOLISM FOLLOWING INJURY TO EXTREMITIES*

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THE clinical problems which confront the surgeon in the management of patients with peripheral venous thrombosis or its dreaded consequence, pulmonary embolism, are still numerous and controversial. Some patients recover rather rapidly after fracture of long bones while others develop painful, swollen legs which require months for the return to normal function. Fatal pulmonary embolism often develops after fracture of the neck of the humerus or intra-articular fractures of the knee.

The general incidence of venous thrombosis in patients who have sustained injury to the legs is almost 12 per cent while venous thrombosis in the general surgical patients occurs in this part of the country in approximately 2 per cent of hospitalized patients.

In evaluating the definitive treatment of venous thrombosis we must constantly give proper consideration to the alterations in the clotting mechanism of the blood, to the age of the intravascular blood clots and finally to the stasis of blood which may follow the interruption of large veins.

The immediate dangers of pulmonary embolism following peripheral venous thrombosis have aroused so much interest among surgeons that there has been a tendency to minimize the serious late effects, such as residual edema, persistent pain or chronic induration of the lower legs with or without ulceration of the skin. It is our firm conviction that prevention of the complications which result from peripheral venous thrombosis is the real solution to the problem, but such a solution can only come as a result of a more universal understanding of the contributing causes, the anatomic sites where most of the intravascular blood clots form and the pathologic physiology of venous thrombosis.

Gunnar Bauer[1] of the Mariestad Hospital in Sweden found that the incidence of venous thrombosis among his general surgical patients was 1.6 per cent and of this group with active venous thrombosis one of every six had fatal pulmonary embolism. During a three-year period he studied 274 patients who had had trauma to one or more extremities and found that thirty-three (or 11.9 per cent) of them had developed peripheral venous thrombosis.

His analysis of these thirty-three cases of venous thrombosis is as follows:

	Cases	Venous Thrombosis	Incidence (Per Cent)
Fracture, neck of femur	47	7	15
Fracture, shaft of femur	25	1	4
Fracture, knee joint	19	4	13
Fracture, lower leg	52	5	10
Fracture, malleolus	25	3	7
Traumatism, knee	43	3	12
Traumatism, thigh	30	4	21
Traumatism, lower leg	33	6	18
	274		

From the Medical Examiner's Office of New York City Vance[2] reported sixty cases of pulmonary embolism following trauma. His analysis of these cases, all of which were fatal, is as follows:

Fatal Pulmonary Embolism Following Trauma

		Per Cent
Fracture, femur	14	23
Fracture, tibia and fibula	11	18
Fracture, tibia	2	3
Fracture, fibula	7	12
Fracture, pelvis	5	8
Traumatism, lower extremity	11	18
Traumatism, trunk and head	10	17
Total	60	99

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Vance[2] found that the site of origin of the blood clot in the majority of his cases was in the large veins of the traumatized extremity. Among the cases of fractured pelvis the site of venous thrombosis was in the pelvic veins.

Martland[3] reported a series of eighty-six cases of peripheral venous thrombosis with fatal pulmonary embolism in which fifty-five were associated with trauma to the lower extremities.

		Per Cent
Simple fracture	37	67.2
Compound fractures	7	12.7
Contusions, bruises	9	16.3
Sprained ankle	1	01.8
Stab wound of thigh	1	01.8
Total	55	99.8

The remaining thirty-one cases followed surgical operations. In this group there were two incidents of fatal embolism occurring after the remanipulation of the fractures of the neck and shaft of the femur, two weeks and ten days following injury.

At the Cincinnati General Hospital, during a period of three months at which time one of the authors (F. B. A.) was the resident on the Fracture Service, ninety-two cases of fractures of the pelvis or lower extremity were admitted to the hospital; among this group there were twelve cases of venous thrombosis with or without pulmonary embolism. An analysis of these cases is as follows:

Analysis of Twelve Cases of Traumatic Venous Thrombosis

	Venous Thrombosis	Venous Thrombosis with Pulmonary Infarction	Pulmonary Embolism
Fracture, femur			
neck	2	..	1
intertrochanteric	2		
shaft	1	1	
supracondylar	..	1	
Fracture, tibia and fibula	2		
Fracture, tibia, fibula and pelvis	1		
Fracture, pelvis and spine	..	1	
	8	3	1

CLINICAL SIGNS OF VENOUS THROMBOSIS

Not infrequently venous thrombosis in the extremities is overlooked by hurried rounds and inattention to minor complaints of the patient. We believe that regular and frequent examination of the thighs, calf muscles and feet of all patients is essential to the diagnosis of the initial phases of venous thrombosis. This point has been emphasized by Allen[4] at the Massachusetts General Hospital who stated "It is not at all uncommon now to have these signs picked up before the patient is aware of any disturbance or before the chart indicates that there is this complication impending." We agree with his recommendations that we should pay particular attention to whether the veins are filled or empty, the presence or absence of tenderness in the calf muscles and presence of pain on forceful dorsiflexion of the foot (Homan's Sign).[10] We believe that it is important that during palpation of the deep veins of the leg the leg should be slightly flexed at the knee and at the hip in order to relax completely the muscles of the leg.

Measurement of the circumference of the extremity at various levels is not of great clinical importance because of the great variation which occurs when such measurements are made at different times of the day. We believe that greater emphasis should be placed on the degree of tenderness in the muscles of the calf, pain on dorsiflexion of the foot and tenderness along the course of the popliteal or femoral veins. These clinical findings are all the direct result of the pathologic changes which Hunter and associates[5] reported in the smaller veins of the muscles of the calves in these patients.

In order to make an adequate examination of the patient's lower leg we do not hesitate to bivalve the cast and completely remove the upper half. Some of our patients were in a modified type of Russell's skeletal traction or the fractured hip was pinned with a Smith-Petersen nail or Austin-Moore pins. In one of our patients who had sustained a fracture of the tibia it was not until the leg had been carefully examined several times following bivalving of the cast that we were able to make a definite diagnosis of venous thrombosis.

PREVENTION OF VENOUS THROMBOSIS

It is well established that there are many factors which influence the return of blood

from the deep veins of the extremities. The action of the heart and squeezing action of the muscles of the legs are the two most important factors. Gravity may either hinder or accelerate the return of blood from the extremities to the heart.

not believe that this is the final answer to the problem since many surgical patients who are active and ambulant from the day of operation have still developed signs and symptoms of a venous thrombosis. Patients with extensive fractures or severe trauma to the lower ex-

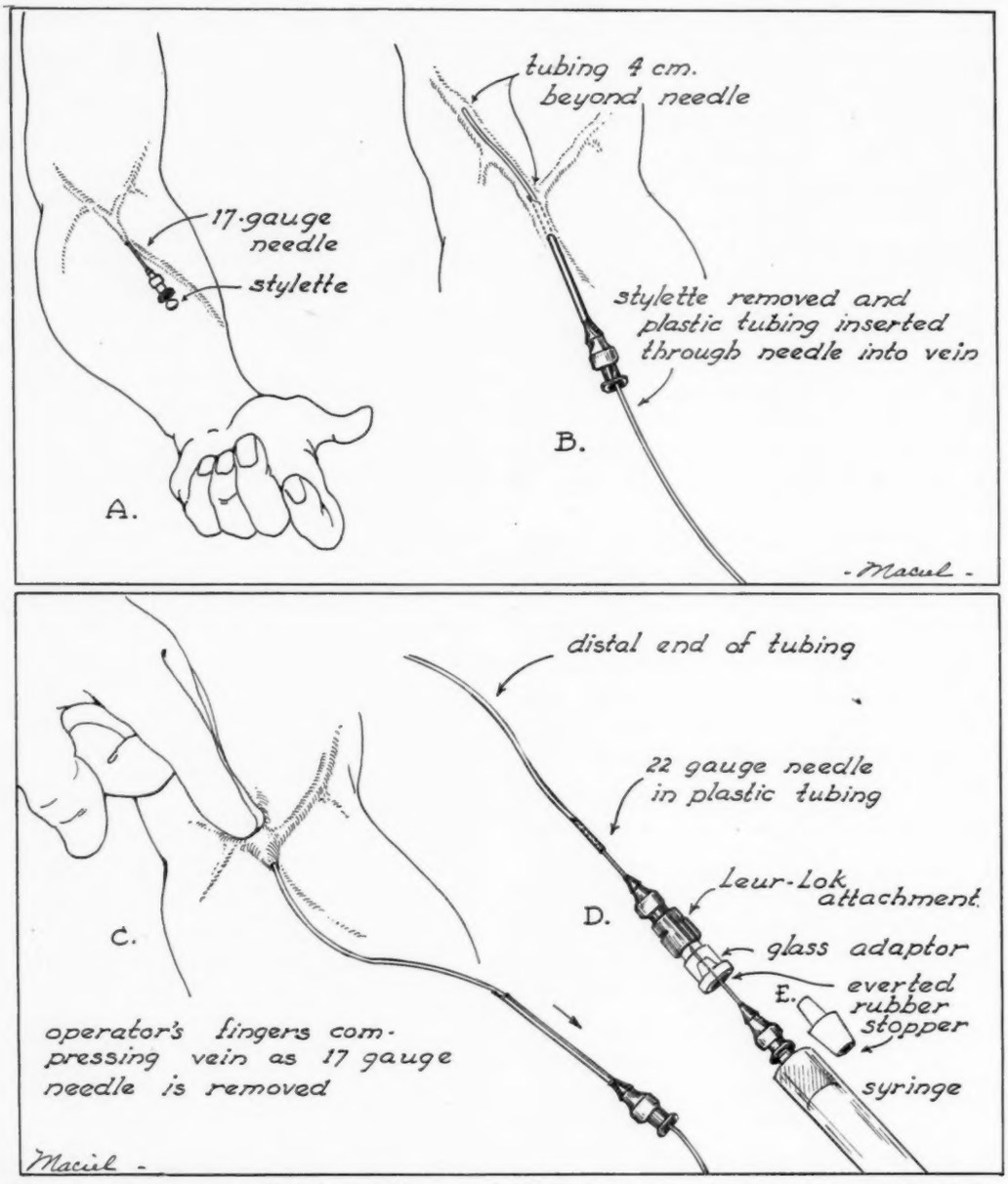

FIG. 1. A, a 17 gauge needle is inserted into a vein of the forearm; B, the stylet is removed and the polythene plastic tubing is threaded through the needle into the lumen of the vein; C, digital pressure is applied over the plastic tubing while the 17 gauge needle is removed; D, a 22 gauge needle with Leur-Lok attachment and glass adaptor is inserted into the free end of the plastic tubing. Heparin is injected through the rubber stopper.

Most surgeons are cognizant of the importance of early mobilization of patients as a means of combating the retardation of the flow of blood from the extremities. We do

tremities are usually not able to become ambulatory. DeCourcy[6] showed that elevation of the foot of the bed by a chair or wooden blocks is an excellent simple procedure for accelerating

the venous return from the lower extremities. DeTakats[7] has emphasized the importance of including the pelvis in this postural drainage. Those patients who are in modified Russell's skeletal traction are encouraged to perform the usual quadriceps muscle exercises as well as exercises of the anterior and posterior tibial muscle groups. Patients whose lower extremities are immobilized in plaster casts should still be able to carry out exercises of the toes.

Smith and Allen[8] showed that the temperature of the skin has an important influence upon the return of venous blood from an extremity. The flow was decreased when the skin was cool and greatly accelerated when it was warm. They also showed that two minutes of active movement of the muscles of the leg while the patient was in the supine position hastened the return of venous blood. Similar results were obtained by raising the extremity to an angle of 30 degrees.

METHODS OF TREATMENT

Once thrombosis of the peripheral veins takes place the objects of treatment are to limit the extension of the process of thrombosis, to prevent fragments of the blood clot from becoming dislodged, to prevent pulmonary infarction and to correct local impairment of the venous circulation in the affected extremity.

At the Cincinnati General Hospital we have adopted the use of the anticoagulants heparin and dicumarol as our primary measure of therapy for venous thrombosis. We believe that elevation of the involved extremity as well as absolute bed rest during the initial period of anticoagulant therapy, followed by ambulation when the local signs have subsided are valuable adjuvants in treatment of this condition.

As soon as the diagnosis of venous thrombosis is made the coagulation time (capillary tube method) and prothrombin concentration (Quick's method) on peripheral venous blood is determined. If the values are within normal limits, heparin and dicumarol are administered.

Heparin is given by the intravenous route in doses of 50 to 75 mg. every three or four hours depending upon the sensitivity of the patient to this substance. We have found that the utilization of polythene plastic tubing which was made available to us by Dr. Kenneth Thompson of the Roche-Organon Company has simplified this intermittent intravenous administration of heparin. This method consists of inserting a 17 gauge needle with stylet into the antecubital vein. (Fig. 1.) The stylet is withdrawn and the polythene plastic tubing is threaded through the needle into the lumen of the vein. The needle is withdrawn and the polythene plastic tubing is allowed to remain within the vein. The tubing is anchored to the skin with adhesive tape after a small piece of gauze has been placed at the site of perforation of the skin. (Fig. 2.) A 22 gauge needle with Luer-lock and rubber stopper attachment is inserted into the lumen from the free end of the polythene plastic tubing. The air is removed from the rubber stopper attachment and heparin is injected by means of an ordinary hypodermic needle and syringe. This method offers several advantages over the usual method for intermittent injection of heparin, the most important of which is the ease with which the nurses may give the heparin intravenously at regular intervals. Because of lack of adequate nursing help, continuous intravenous administration of heparin has been discontinued in our clinic.

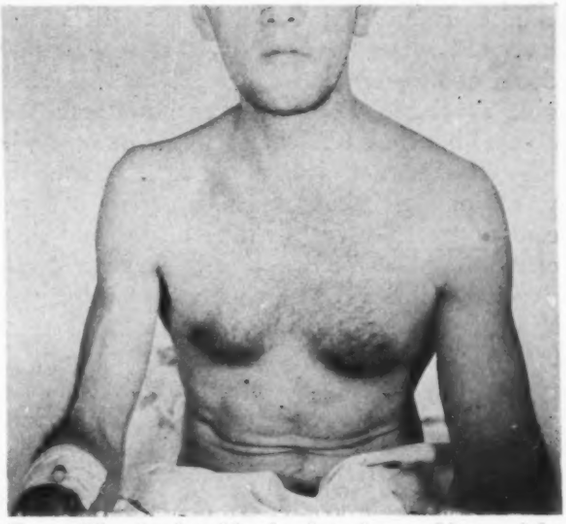

FIG. 2. The plastic tubing has been inserted into a right forearm vein, the attachments added and anchored with adhesive tape.

When the initial prothrombin concentration is within normal limits we administer 200 mg. of dicumarol simultaneously with the initial dose of heparin and then give 200 mg. on the following day. Since the majority of these patients were in the older age group, we have tried to avoid any sudden increase in the blood volume with transfusions of whole blood to

counteract any hypersensitivity to dicumarol. Even though we have employed relatively small doses of dicumarol, we have been obliged to give synthetic vitamin K to counteract abnormal bleeding tendency. In one patient who showed abnormal sensitivity to this drug the prothrombin concentration dropped to 6 per cent of normal after the initial dose, and signs of bleeding became apparent. This patient also developed femoral nerve palsy which has persisted up to the present time.

On our service the duration of therapy is ten to fourteen days during which time the patient is made ambulatory if at all possible. If the patient is confined to bed because of the method used in treatment of the fracture, dicumarol therapy is continued for the duration of the period of bed rest. Under the latter circumstances prothrombin concentrations are obtained two to three times a week and a sufficient amount of dicumarol is administered to maintain a prothrombin concentration between 30 and 50 per cent of normal.

All but one of our patients received anticoagulant therapy; of those who received heparin and dicumarol the symptoms subsided within two to four days. Patients with pulmonary infarction did not show evidence of further pulmonary embolism on either physical or roentgenologic examination. One patient who had a fracture of the neck of the femur died with a massive pulmonary infarct. Owing to her feeble-mindedness and comatose condition for one week prior to death, the venous thrombosis was unrecognized. She refused to eat and developed, in addition, a mixed meningitis as an extension from a sacral decubitus ulcer.

SUMMARY

The causes or abnormal circumstances responsible for the intravascular clotting of blood are not yet fully understood. Workers in this field do, however, recognize the fact that the real solution to the problem lies in the prevention of venous thrombosis rather than in limitation of the process to the part of the extremity already affected. It is most important, therefore, to examine each patient carefully for evidence of venous thrombosis so long as he remains bedridden.

Among patients with fractures of the lower extremities there is a high incidence of elderly people who are particularly susceptible to the development of venous thrombosis. Since the occurrence of deep venous thrombosis is so closely related to inactivity and recumbency, early and continued active motion while the patient is still in bed is an important prophylactic measure. Measures preventative of stasis of blood in veins of the lower extremities such as frequent change of position, elevation of the foot of the bed and, most important, movement of the muscles of the lower extremities must be carried out.

Once peripheral venous thrombosis has occurred early recognition of its presence is essential to proper therapy. At present we believe that limitation of the disease process to the affected extremity and the prevention of pulmonary embolism is best accomplished by the use of anticoagulent therapy.

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DISCUSSION OF PAPERS BY DRS. BREIDENBACH AND LORD AND AURIN AND HERRMANN

Louis G. Herrmann (Cincinnati, Ohio): Dr. Breidenbach and Dr. Lord have rightfully emphasized the importance of early recognition of injuries to large blood vessels in any form of trauma. It is

also important that whenever possible the continuity of blood vessels be re-established as quickly as possible, for every hour that passes after complete arterial occlusion or cessation of arterial circulation to the various parts of the extremity increases the hazards.

There are some exceptions to this, and Dr. Breidenbach probably did not have the time to tell them all. It is our belief that whenever blood collects under fascial planes and causes a collapse or interference of the collateral circulation, immediate operation should be done even though the continuity of the artery cannot be re-established.

I do not entirely agree with Dr. Breidenbach or Dr. Lord in the management of arteriovenous aneurysm. We know that is a very powerful stimulant to arterial collateral circulation and it is not always possible to re-establish the continuity of the artery. Some people have tried to do so in the vein, and whenever veins are re-established under those circumstances, pulmonary embolism is a frequent complication. I should like to warn you that repair of veins, especially in arteriovenous aneurysms, is dangerous.

Dr. Breidenbach did not have time to say anything about the late effects of arterial injuries; the complications which follow injuries to large blood vessels sometimes come on very insidiously and they go unrecognized until some irreparable damage to the soft tissues of the extremity already have taken place.

Concerning Dr. Aurin's paper we are particularly anxious that early recognition of minimal types of venous thrombosis be made. We are sure that if treatment is instituted early, many of the serious complications can be avoided. Unfortunately, we do not see as much venous thrombosis in our own clinic as has been reported from some of the other clinics throughout the country. We are constantly on the lookout and, of course, in the management of fractures we see patients who have been exposed to trauma and therefore are ideal candidates for venous thrombosis.

At the present time we are interested in finding some adequate test for the susceptibility to venous thrombosis. The prothrombin test, even with concentrated plasma, does not give us the complete story as to which group of patients is particularly susceptible to venous thrombosis. It is our hope that some time in the near future a good test will be available so that elective operations can be postponed if the individual is in a phase of hypercoagulability of the blood.

Charles G. Johnston (Detroit, Mich.): It is common practice in our hospital (and many times we are criticized for it) to re-suture an artery which might well be tied off without damaging the limb. We have gone on the major premise, in teaching, that the staff is there as teachers, the residents as surgeons, and that under those circumstances it takes a great deal of time from the staff man because it means that he can do the operation in less time than the resident can. Nevertheless, as time goes on, these men get very agile and in some instances do the work quicker and better than even the staff man could.

It is the same in relation to arteries. We have made it a rule that any major artery that is cut must be sutured. When the resident first sutures an artery, even though he has had practice in the animal laboratory, he is somewhat concerned about it. I think it is pretty generally true that after one artery has been sutured successfully the confidence which is gained makes a great deal of difference.

It is very important primarily for the development of technic, because many limbs are lost because the surgeon believes that arterial suture is something that is strange, phenomenal, unusual and difficult to do.

We do not have all the equipment that Dr. Lord has presented. It is very nice to have it but one does not need all this equipment to do an arterial suture. I think this is important to point out. One does have to have some way of occluding the vessels and also suture material and needles which are of the proper size.

I have had no experience with Vitallium tubes in general, because I think the thing can be done just as well and just as easily without them. I see no need for Vitallium tubes and am opposed to the use of foreign bodies in places where straight grafts can be used. I much prefer to use a vein graft without the use of Vitallium tubes. I am of the same opinion in relation to the use of Vitallium tubes for restoration of the common duct.

One question I would like to ask is about removing the clot from the distal portion of the vessel. In a vessel that is injured the upper portion can easily be washed free of any clot and usually there is none there; but in the distal portion there is a tendency for clot formation. If this is not carefully removed, one finds later that thrombosis in the terminal vessels results.

It is sometimes exceedingly difficult to remove, in my experience, all the clot that is below. I would like to ask the authors what means or to what lengths they go to be sure that the distal portion of the artery is clear of clot?

In one instance we have made an incision further down in a patient who had his injury for some time in order to wash through from the suture site, so that all clots could be washed out. Even in this instance although we had removed clots from above the lower incision, opened the artery well down the leg and allowed blood to flow, we had a certain amount of thrombosis which developed in the terminal vessels.

Gordon Murray (Toronto, Canada): In the first paper on repair of vessels and grafts, I am entirely in accord with all the views expressed. I

would like to emphasize this point: When an extremity is injured and there is a huge hematoma with obliteration of pulse distally, it should be explored under average conditions. It should be determined at the time whether the vessel is completely divided or not and an appropriate repair carried out.

We are interested in sewing vessels and in putting grafts to bridge gaps. What is the fate of those grafts? I have some information that has come to hand recently concerning the survival of grafts. I put a venous graft in a brachial artery eleven years ago and it is working well at the moment. Another graft in a popliteal artery twelve years ago was 5 inches in length, and I have reason to believe it is still working well. Another graft in a femoral artery has been working for ten years. This boy went into the Army, went overseas, returned and is still well. This graft has stood him perfectly well.

These among many others have been under observation recently and there is no sign of giving way of the graft; there is no aneurysm, degeneration or calcification that can be felt or seen on x-rays. However, probably the best evidence is an experimental graft which I put in the carotid artery of a dog. With good care he lived for nine years. We got that graft a few weeks ago after the dog died of old age. The lumen was patent and a little larger than the adjacent artery, but it was functioning normally. There was some calcification and some bone in one part of the wall; otherwise it was clear inside. The endothelium looked normal and it was functioning normally after nine years.

Regarding the second paper on venous thrombosis by Drs. Aurin and Herrmann, again I am entirely in accord with their opinions. It is my view that venous thrombosis occurs more commonly than it is considered by staffs in hospitals.

Regarding the prevention of embolism following thrombosis, I have some very definite views based on the following evidence. Some believe that vessels should be tied off early either before or after operation to prevent embolism. I have now seen three patients who died of proven pulmonary embolism following simple ligation of the saphenous vein in Scarpa's triangle for varicose veins.

Another patient recently sent to me had had a hysterectomy and the surgeon had tied off her veins as a precaution. Having anuria, she was sent to me for treatment with the artificial kidney. To get into the vena cava we opened the veins that had been tied off as a precautionary measure to prevent embolism. As I took off the ligatures and went through the saphenous bulb and into the femoral vein, I pulled out a clot on the left side a foot long that had extended through the femoral vessels and into the vena cava. The operation that had been done to prevent such a condition had probably caused it.

We probably all agree that at operation the tying off of any vessel is the site at which thrombosis must necessarily begin, but how far it extends no one can tell. At any rate, in these cases the ligation of vessels was one factor in producing thrombosis and intravascular clotting.

Therefore, I am very much of the opinion that the treatment for thrombosis and pulmonary embolism is anticoagulants. I am somewhat prejudiced in favor of heparin but we use dicumarol as well. I hope the day may come when it will be possible to give anticoagulants as a prophylactic to patients susceptible to thrombosis.

JOHN A. CALDWELL (Cincinnati, Ohio): I have gone through the experience over a long time of watching venous thrombosis gradually develop. It is detected first when the thigh gets large and painful and the patient exhibits a rise in temperature.

Since we have become thrombosis-conscious, it is a common thing after watching the patient and looking at the condition to note the tenderness in the calf of the leg, the presence of a positive Homans' sign and so discover the condition early, and as a result to get the patient convalescent very much sooner. It has been a distinct contribution to our handling of these cases and I wish to testify to that particularly.

In discussing the first paper Dr. Herrmann quoted me as giving him information about damage to the popliteal artery associated with the displacement of the lower epiphysis of the femur. I should like to call further attention to this and give warning because in both of them the children who had this condition lost their legs. Where the lower epiphysis separates, it is nearly always displaced anteriorly and this displacement stretches the popliteal artery over the ragged edge of the upper fragment. If this condition is not relieved promptly the continued pulsation of the artery over the ragged edge will gradually wear it in two.

In both the cases which I have seen (these were not mine originally) the restoration of that displacement was delayed long enough to permit the catastrophe to take place, and when it does happen it is a real catastrophe.

HOWARD SNYDER (Winfield, Kan.): Arterial injuries were very important subjects in military surgery. Fortunately, we had the opportunity of using some of the Lord-Blakemore tubes in the Mediterranean theater. Dr. Allen O. Whipple was responsible for having some of them sent to us early, and our own Ordnance Department made us a lot of these tubes, so that a number were used.

We found it rather difficult to evaluate results. The artery injured, the extent of the damage to collateral circulation and concomitant wounds in the same extremity certainly influenced the prognosis and result.

Dr. F. A. Simeone, I am told by Dr. Lord, has reported on a series of these cases in the Mediterranean theater. It was hard to say from the first dozen of these cases whether or not we were improving our results with the Lord-Blakemore tubes. One of the complications occurred that Dr. Lord mentioned: A vein graft blew out about two days after the graft was made. That case would have been one of the good results but with reoperation the limb was lost.

One of the things that must be considered in the use of a graft is the fact that the added manipulation may further interfere with the collateral circulation. I think whenever one of the operations is attempted that should be kept in mind, and trauma of the collateral circulation certainly should be minimized.

Popliteal injuries almost invariably resulted in the loss of a limb if arterial continuity was not restored, and certainly in that case a graft should be attempted.

In wounds to the femoral artery the results were as good with ligation as they were with the use of the tubes in the cases I had an opportunity to observe. I hope Dr. Lord will tell me if this was not true in the total series of cases that Simeone reported.

Certain other things might be mentioned which are important in the care of these arterial injuries. Primary suture can be done successfully in the case of the popliteal artery even when there has been some loss of substance. Imes reported three cases in which he did a primary anastomosis and saved the limb. Lichtenstein called attention to another maneuver which may save life or limb, and that is the use of suture of the end of an artery rather than ligation to preserve collaterals which may be close by. He called attention to that procedure in the management of wounds of the larger arteries in the neck.

Sympathectomy was made almost a routine procedure following these vascular injuries. A slightly dependent position of the limb, careful attention to other wounds of that extremity and the use of fasciotomy or long incisions through the skin and fascia to decrease tension in the affected limb were thought to be of value in the management of these cases.

JERE W. LORD, JR. (New York, N. Y.): The successful management of arterial anastomosis rests on the basic triad: proper vascular equipment, "know-how" of arterial anastomosis and practice and experience. Many successful anastomoses have been done by the surgeon who has improvised his equipment at the time, and have also been done successfully when the surgeon has had no previous experience but has done it at the time because of necessity. In general, however, the ideal is to have the equipment available in every hospital where it is necessary to carry out these procedures, and, secondly, have a surgeon on hand who is experienced with the technic; this, of course, is most important.

In addition to having the equipment and the experience, technical proficiency can be obtained in the department of experimental surgery so that each surgeon interested in this subject will be prepared to handle this emergency in hospitals which do not have a large volume of clinical material of this sort.

LESTER BREIDENBACH (closing): It is true that in most injuries that occur the surgeon attempts to tie the artery; and in the one case we cited in which this accident happened in the course of a herniotomy, it was the first experience we had had in going back late after the artery had been ligated.

Due to technical errors it was not successful but that sort of procedure can be done in spite of the fact that the limb, as Dr. Snyder mentioned, may not be gangrenous when the injury is high up on the femoral artery. The limb may be saved but usually the function is badly impaired. The individual can walk for only a short distance without claudication and pain. Efforts should be made in late cases in which the limb has been saved and the function impaired to re-establish anastomosis and the use of the artery.

Dr. Aurin mentioned some of the late results and he does bring out the fact that the vein graft arterializes beautifully. On microscopic examination it is very difficult to distinguish the vein graft from an artery.

We have felt so strongly about this that the New York and Brooklyn Regional Committee on Fractures and Other Trauma, under the chairmanship of Dr. Wade, has developed a brochure with instructions to surgeons on the management of these particular injuries, with all their ramifications, the method and equipment.

In answer to Dr. Johnston's question I wish to state that on the removal of thrombi from the distal end of the artery, a great deal has to do with the time factor. If the injury is seen very early, there is not much chance for thrombosis and it does not extend very far. We dissect the distal end of the artery as great a distance as we can from the site of the injury, put a rubber-shod clamp or two turns of umbilical tape to prevent thrombi from going distally and then thoroughly irrigate that artery. In spite of that, as Dr. Johnston has brought out, we are not always successful in removing all of the clots; but that has been the best method, thoroughly irrigating with a stop somewhere down low in the artery, that is, as low as one can possibly get.

LOCAL APPLICATION OF ALUMINUM FOIL AND OTHER SUBSTANCES IN BURN THERAPY*

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THIS paper deals chiefly with the results of investigation directed toward improvement of the local therapy of thermal burns. Because of the encouraging observations noted on the application of aluminum foil as a primary dressing, this section of the work is described in detail. In addition, mention is made of three other studies. (1) use of titanium dioxide exposure cream as a topical application for thermal burns. (2) use of massive doses of ascorbic acid in the early therapy of acute burns and (3) blood glutathione levels in children following acute burns.

ALUMINUM FOIL THERAPY

It is possible in deep second degree burns that maceration of the burn surface may result in the death of cells which might otherwise remain as islands of regenerating epithelium. Prevention of this maceration is considered to be an effort of some importance.

For centuries ointments of various types have been applied to burned surfaces. In many localities gauze impregnated with vaseline is employed as a regular procedure. Woven fabrics, used with or without ointments, may become soggy with exudate thus aiding in the production of maceration. On the other hand, a dry non-absorbent covering, virtually intact, may be of advantage because of these physical properties. Many metal foils may be suitable. As aluminum is non-toxic and the foil is plentiful, cheap and easy to sterilize it was the metal employed in most of the cases to be described.

Application of metal foil as a surgical dressing is far from new and dates back at least to the time of Lister[1] who advocated the use of tin foil or sheet-lead from tea chests as a covering for wound dressings. More recently Davis[2] has applied foil to freshly grafted areas and Harkins[3] describes the use of silver foil on donor areas and grafts.

Physical Properties. Pure aluminum foil is a bright metallic sheet which, at a thickness of .001 inches, can be readily molded on the contours of the body surface and removed with the dressings at ten days. Thicker foils were found to be more unwieldy at the initial dressing. On the other hand, foil as thin as .0004 inches has been used and although it could be applied with ease fragmentation occurred under occlusive pressure dressings, with the result that its removal piece by piece from the burn surface on the tenth day was tedious. Lately use of this thin aluminum foil has been reserved for application on fingers and hands, in which case the ease of application in the treatment of children has far outweighed the inconvenience of piecemeal removal.

As a result of the process of manufacture as well as the manipulation in handling all foils were found to be permeable sheets. Pin holes transmitting light could readily be seen when a sheet was held up to a source of light. To test for permeability to liquids aluminum foil, .001 inches in thickness, was molded into the form of a flask and filled with water. Numerous small drops appeared immediately on the exterior at the sites of these tiny apertures. No samples were found to be water-tight.

Method of Application. The standard method adopted for application of aluminum foil to the burn surface at the initial dressing is as follows:

1. Following adequate sedation, the burn area is cleansed under aseptic precautions with 1 per cent aqueous cetyl-trimethyl-ammonium bromide (cetavalon); sluiced clean with saline and blotted dry with a sterile towel.

2. Dry aluminum foil which has been sterilized by autoclaving is smoothed by hand onto the burn surface and is extended at least 1 inch beyond the burn on the undamaged skin.

3. The routine pressure dressing is then applied over the foil. This includes voluminous

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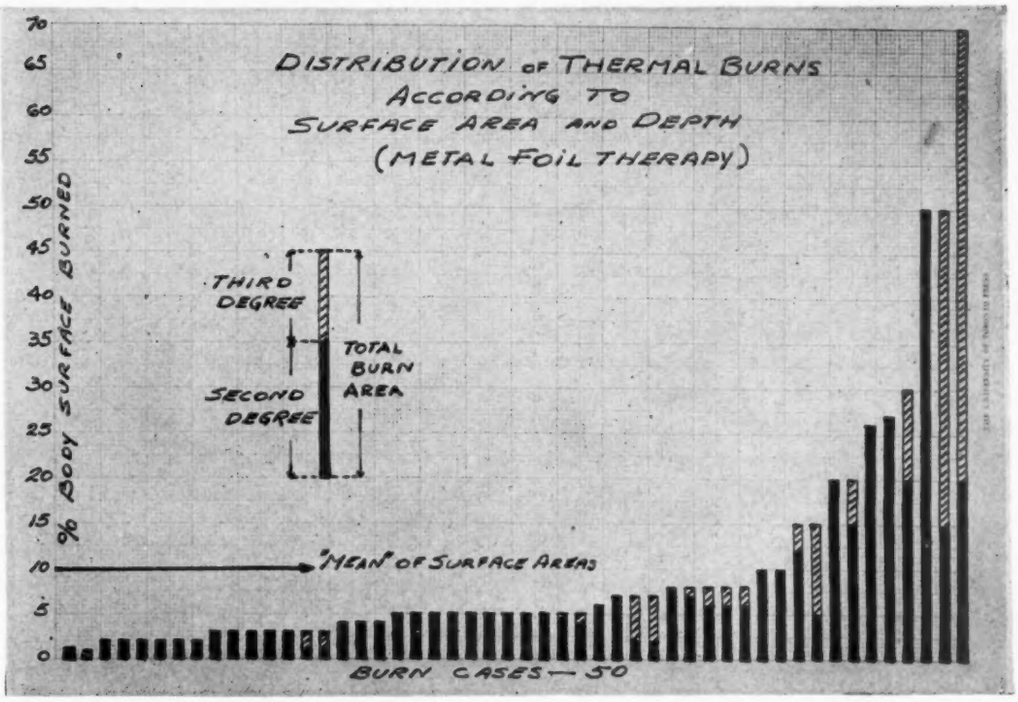

FIG. 1. The area and depth of the injury to each of the patients on whom metal foil was applied is indicated in this diagram.

fluffed-out gauze and burn pads with bias flannelette bandaging. In order to ensure immobilization in children light plaster casts complete the dressing when indicated.

Results. To date fifty children have been admitted to the hospital for Sick Children, Toronto, Canada, for whom aluminum foil* has been used as an initial dressing for thermal burns. In some cases gold leaf, silver leaf, tin foil or tantalum foil supplemented the aluminum foil on a portion of the burn surface. The ages range from five months to thirteen years, with burns of varying size and depth from 1 per cent second degree to 70 per cent second and third degree. Erythema was not included in the estimation of the burn surface area. Using the burn classification of three degrees, rather than Dupuytren's classification, the distribution of the burns according to body surface area and depth is recorded in Figure 1.

Many factors, such as the area, depth and condition of the burn surface as well as the type of local therapy, play a part in the systemic reaction of a burned patient. For clarity in the analysis of the problem the local and systemic aspects of the cases will be dealt with separately.

INFLUENCE OF LOCAL THERAPY ON THE BURN SURFACE

In thirty of the fifty cases which were studied approximately similar results were found at the ten-day redressing on removal of the foil from burns which were second degree in depth only. The burn surface was pink, dry and found to be healing by epithelization without evidence of the maceration so often found with ointment dressings into which exudate has soaked.

The aluminum foil maintained its dry metallic sheen on both surfaces. The gauze dressings protected by the foil were unstained except for small spots of dried brown exudate which on occasion had penetrated the tiny apertures in the foil. At the periphery of the foil some exudate was seen in the voluminous gauze dressings resting on normal skin. This exudate was dry, scant, brown in color and had evidently flowed laterally by capillary action between the foil and the body surface. The observation that the exudate had dried emphasized that the weeping from the burn surface had ceased some days prior to the first redressing. The ten-day dressings were practically odorless.

* Aluminum foil was supplied by Dr. Dudley Irwin of the Aluminum Company of America. The product referred to as 2S-O, contains 99.3 per cent reduced aluminum, 0.1 per cent silicon and the remainder being iron except for traces of copper and manganese.

For purposes of comparison vaseline gauze and aluminum foil were placed contiguously on a portion of the burn surface in three of these patients, resulting in a clear cut line between the two forms of local therapy. At the ten-day period moist exudate continued to soak the fabric, and maceration of tissues under the vaseline gauze was distinctly noticed in contradistinction to the dry healing surface under the foil.

In one case, for further comparison, dry nainsook was likewise applied to an area surrounded by aluminum foil. As compared with the dry clean epithelization of the area under the latter the area under the nainsook showed a sharp contrast with adherent heaped-up exudate and the material itself was soaked with moist exudate. This served to demonstrate the fact that the vaseline application *per se* is not exclusively the factor causing maceration.

In nine further cases the local results at ten days warranted a common description of the burn areas which were third as well as second degree in depth. On removal of the foil the second degree areas were dry and healing. The third degree areas were covered with a thin, moist, grey layer of slough. The skin surface of the aluminum foil was slightly moist but the bright metallic sheen was unchanged. The gauze dressings contained a moderate amount of dried brown exudate at the periphery, but the gauze protected by aluminum foil was clean. This group included one burn of third degree depth over 35 per cent of the body surface with an additional 15 per cent second degree. As in the smaller burns of this group this case revealed no evidence of the foul-smelling exudate which would almost certainly have been a feature of ointment dressings in burns of this extent and depth.

In three further cases including burns of second and third degree the dressings were extensively soiled with urine by the tenth day. The skin surface of the aluminum was moist and the overlying gauze was soggy. The dressings had a foul uriniferous odor. Burn areas of third degree depth were covered with thin, moist slough while second degree areas were likewise moist but healing with pink epithelium. There was no clinical evidence of infection. The third degree areas corresponded in extent to the areas suspected to be full thickness burns at the initial dressing and following repeated applications of sodium hypochlorite solution, 1:12, the areas were grafted.

An additional two cases included second degree burns of the hands which were treated by application of aluminum foil with individualization of the fingers. The tenth day redressing disclosed marked maceration of the burn surface, and the superficial skin layers were wrinkled, soggy and whitened. These results were in contradistinction to ten other cases of hand burns which have been included in the large group of second degree burns with dry cleanly-healing results at ten days. The reason for the maceration in these two burns is believed to be due to failure to apply adequate pressure with the bulky mitt-like dressings.

In one further case aluminum foil was applied to second degree burns of a leg and the overlying dressings were deliberately applied with minimal pressure. The burn continued to weep through the voluminous gauze which was reinforced on two occasions. The burn surface at the tenth day was moist and moderately macerated and the dressings contained more than the usual amount of exudate.

One further case was a deep second degree complete facial burn in a fifteen months old child. Aluminum foil was applied over the entire surface, including the eyelids, and covered with voluminous dressings, leaving an opening for the mouth. Because of concern for the eyes, redressing was performed at the fourth day. The entire skin surface of the foil at this time was found to be wet as a result of lacrimation and seepage under the foil. Moist brown stains were scattered on the overlying dressings where the fluid had penetrated the apertures in the foil. The gauze dressings at the margins of the foil were likewise moist. The burn surface was pink and healing cleanly except for a grayish-brown covering on the upper eyelid areas. Aluminum foil was reapplied, leaving the eye areas uncovered. By the tenth day epithelization was progressing satisfactorily and cleanly except for crust formation on the upper lids. Satisfactory healing was eventually completed without the necessity of grafting. Among the second degree burns with dry cleanly healing results was included a similar full facial burn in an older child, and the eyelids were not covered in this case at the initial dressing. Four other second degree burns involving partial facial areas

only were also included in the same group just described. One full facial third degree burn treated with local application of aluminum foil was included in the large group of third degree burns which have been described. The result was indistinguishable from the third degree burns elsewhere on the body, and grafting was done at the sixteenth day with a complete "take," including the eyelid areas.

One of the remaining patients suffered third degree burns over 50 per cent of his body surface and second degree burns over an additional 20 per cent. Although the dressings overlying the aluminum foil were quite dry at ten days and compared favorably with the previously mentioned description of the group of nine second and third degree burns, this case differed in that the burn surface was covered with a leathery green slough due to infection with Bacillus proteus and B. pyocyaneus, rather than with the thin, moist, grey slough which had been the usual result of third degree areas treated with local application of aluminum foil. This was the one case in which gross clinical evidence of infection was found in these fifty cases. Extensive bacteriologic studies of the organisms on the burn surfaces have not been possible, and stress instead has been laid on clinical evidence of pathogenicity rather than bacteriologic evidence of contamination.

In one of the remaining cases dry cellophane was applied to a portion of the burn surface for purposes of comparison with aluminum foil applied elsewhere. At the tenth day the cellophane was soggy and adherent to a thick layer of slough. The dressings at the periphery were soaked with foul-smelling exudate which had extended by contact to the layers of gauze overlying the peripheral portion of the cellophane. Only the central portion of the overlying gauze was clean by reason of the distance from the periphery and the protection from direct penetration afforded by the cellophane barrier. By comparison with the result of the use of aluminum foil on this and comparable cases it was evident that cellophane was unsatisfactory and its use was eliminated from the series of cases.

One of the two remaining cases was a small second degree burn which was treated with aluminum foil and the patient was discharged prior to the ten day redressing. The patient failed to return for the tenth day appointment and the result was presumed to have been satisfactory.

The final case to be considered was a small third degree burn caused by an exploding firecracker. The initial dressing was aluminum foil. The burn area was excised and grafted on the fourth day in order to shorten the clinical course. At this stage the dressings were dry, the burn area was without exudate and a central black area had the appearance of dry gangrene. Healing following grafting was uneventful.

ALUMINUM DUST AS A LOCAL APPLICATION

Because of the simultaneous interest in the preparation of a combined exposure cream and burn ointment to be used as an initial emergency measure by air force personnel, aluminum dust was briefly investigated. By a process of Soxhlet extraction with acetone followed by desiccation dry aluminum dust was obtained from aluminum paint.* In the process the aluminum lost a great deal of its bright sheen due to formation of oxide. The aluminum dust (reduced aluminum plus oxide) was sterilized by dry heat and applied to a superficial second degree burn with a result at ten days equal to areas covered by the foil. On one additional third degree burn the dust formed an adherent eschar with the surface slough and exudate which was slow in separating under dressings of sodium hypochlorite 1:12. Whereas third degree areas treated initially by aluminum foil were ready for grafting by the eighteenth day, the areas covered with aluminum dust were delayed an additional two weeks.

There was no evidence of local or general toxic reaction to the aluminum dust which was used. The possibility of the occurrence of the phenomenon of tatoo due to application of the dust to burns of deep second degree depth was discussed but was not encountered as this type of burn was not included in the two cases studied.

LOCAL APPLICATION OF GOLD LEAF, SILVER LEAF, TIN FOIL AND TANTALUM FOIL

Gold leaf and silver leaf were obtained as extremely thin fragile sheets which were difficult to handle because of their static elec-

* Supplied by Dr. Dudley Irwin of the Aluminum Company of America.

trical charge. This caused them to adhere to objects which they contacted when being applied to a burn surface, with resultant fragmentation at the slightest touch. Tin foil, containing 2.5 per cent lead, and tantalum foil were similar in appearance to aluminum foil.

For purposes of comparison portions of the burn surface of nine patients treated with aluminum foil were covered with one of the other four metals and second and third degree areas were included in the comparisons. The local results at ten days in eight cases were equal to the remaining areas covered with aluminum foil and separate descriptions of the burn areas are unnecessary. The gold and silver leaf at ten days was found to be finely fragmented and adherent to the dressings except for scattered traces remaining on the burn surface. The tin foil and tantalum foil were removed intact and unchanged in appearance.

In the other of the nine cases gross infection by B. proteus and B. pyocyaneus was present at nine days under the aluminum foil in the extensive burn case previously described while an area covered by gold and silver leaf totalling 5 per cent of the body surface was covered with a firm adherent brown eschar of surface slough and exudate in which was incorporated the fragmented metal. Further comparison with regard to separation of the areas under sodium hypochlorite dressings was terminated by the death of the patient on the twelfth day.

INFLUENCE OF LOCAL THERAPY ON THE SYSTEMIC REACTION TO THE BURN

In order to evaluate the effect of aluminum foil therapy on the systemic reaction mention must be made of other therapy employed. According to the indications in an individual case, the following outline of treatment was followed: (1) Antitetanus serum 1,500 or 3,000 units and scarlet fever antitoxin 3,000 units were given to all patients. (2) All burns involving 10 per cent of the body surface or more received plasma as well as some burns of lesser extent. The amount of plasma was judged on the basis of the extent of the burn and the hemoconcentration as determined by repeated hemoglobin estimations using the photo-electric colorimeter. (3) Burn patients in whom 10 per cent or more of the body surface was involved as well as those with lesser surface area burns but third degree in depth received a high caloric, high protein diet with added multiple vitamins and iron. Otherwise the patients received the regular ward diet. (4) Fluids were administered freely by mouth, and additional parenteral fluids were administered when necessary to correct or prevent dehydration. (5) Intramuscular penicillin therapy was decided upon for each individual patient and not used routinely (6) Blood transfusion was reserved for severe secondary anemia.

Clinical experience with many hundreds of burn cases at the Hospital for Sick Children has shown that the supportive therapy used was adequate for burns involving less than 10 per cent of the body surface. In this group marked systemic reaction was not encountered. Of the fifty cases thirty-eight are included in this group and no evaluation of the effect of aluminum foil therapy on burn illness can be made. These cases were of value in disclosing the absence of abnormal systemic or local reaction to the aluminum foil itself.

Twelve cases are included in the group of burns involving 10 per cent or more of the body surface. Of these, one patient only progressed through a severely toxic stage and eventually succumbed on the twelfth day to burns covering 70 per cent of his body surface including 50 per cent third degree. Of the remaining eleven patients none gave cause for alarm by reason of general signs or symptoms during the critical period of the first week. In two cases involving 50 per cent of the body surface these were considered to be much milder than was expected with other forms of local therapy despite the most rigorous general supportive measures.

Outlines of the clinical courses of the three patients with the most severe burns are as follows:

CASE REPORTS

CASE 1. A twenty-three month old boy sustained a scald which involved 50 per cent of his body surface in third degree burns and 20 per cent in deep second degree burns. On arrival at the hospital a profound state of shock responded immediately to intravenous plasma and two hours after admission, under morphine sulfate gr. 1/12 (S.C.), the burns were dressed with aluminum foil except for a 5 per cent surface which was covered with gold and silver leaf. During the first twenty-four hours the patient vomited once and never thereafter. His extremities were warm. His pulse rose to 124/minute and respirations were as high

as 60/minute but they were shallow and effortless. Plasma was continued to a total of 1,750 cc. and was followed by Ringer's lactate.

The course of his illness, subsequent to the first twenty-four hours, was definitely a toxic one. He became difficult to arouse, respirations remained accelerated but without evidence of true dyspnea and his temperature rose to as high as 105°F. For forty-eight hours marked oliguria was accompanied by albuminuria, 2 plus urobilin and gross hemoglobinuria which were followed by diuresis and clearing of the urine. Sporadic twitchings of his extremities became frequent. There was edema of the dependent portion of his scalp and the serum proteins fell to 5.3 Gm. per cent with an albumin/globulin ratio of 1. A marked secondary anemia required transfusion. On the ninth day, at the height of a consistently rising septic type of fever, the burns were redressed, hypochlorite solution 1:12 being applied. From the third degree areas covered with green slough B. proteus and B. pyocyaneus were cultured.

During the following three days this patient's condition continued to deteriorate and death ensued on the twelfth day. No single cause of death could be determined at postmortem which disclosed early bronchopneumonia, extensive infection, acute left otitis media and several erosions of the gastric mucosa.

It is perhaps worthy of note that at no time was cyanosis present, no frank convulsions developed and no vomiting recurred despite administration of high protein, high caloric gastric feedings by continuous drip.

Case II. A four and one-half year old boy was treated with aluminum foil dressings two hours after sustaining deep second degree burns over 50 per cent of his body surface. General supportive measures were carried out as first outlined. His subsequent clinical course was mildly toxic. He remained alert throughout, urinary output was unimpaired and urinalysis disclosed 4 plus albumin on the day following the burn but subsequent urinalyses were normal. Fluids and high protein, high caloric diet were tolerated without vomiting. One rectal temperature reading of 104°F. on the first day was followed by fever below 103°F., with a normal temperature from the ninth day on. One unusual pulse reading of 160/min. occurred on the sixth day. Serum proteins were depressed to 4.2 Gm. per cent by the seventh day but rose again to the initial level by two weeks. During the first ten days this patient was quite comfortable considering the extent and severity of the burn and his subsequent course was uneventful with rapid healing by epithelization.

Case III. A seven year old girl sustained third degree flame burns over 35 per cent of her body surface and second degree burns over 15 per cent of her body surface; they were treated by the application of aluminum foil. The initial hemoconcentration was corrected by 1700 cc. of intravenous plasma during the first forty-eight hours. During this time her extremities were cold and cyanotic and vomiting occurred several times. No other general signs were noted. From the third day of her illness she tolerated a high protein, high caloric diet without recurrence of vomiting. During the first ten days her temperature rose to 103°F. on one reading and as high as 102°F. thereafter. One pulse reading of 160/minute was obtained on the fourth day but otherwise the pulse chart of the first ten days was indistinguishable from the chart of the subsequent months of her illness. Dyspnea was not observed. By the eighth day a secondary anemia had developed and she required a transfusion. Serum proteins remained above 5 Gm. per cent and there was no inversion of the albumin/globulin ratio. Urinary output was slightly impaired only and urinalysis disclosed 3 plus albumin on the second day, subsequent occasional traces and occasional red blood cells and white blood cells on microscopic examination.

Grafting was begun on the eighteenth day and was completed by multiple stages during the subsequent four months.

The remaining nine of the twelve patients with burns of 10 per cent or more of their body surfaces showed little or no evidence of general illness except for febrile reactions. A large series of cases of more severe burns will be required from which to draw conclusions but to date burn patients appear to pass through a milder stage of systemic reaction than one has been accustomed to see in comparable patients using other forms of local therapy.

FACTORS TO BE CONSIDERED IN INITIAL ALUMINUM FOIL THERAPY

Several possible factors are under consideration which might, in part at least, account for the apparent favorable results from use of aluminum foil as an initial application for fresh thermal burns.

1. By virtue of the heat-reflecting property of aluminum foil heat conservation may favorably influence the course of the illness.

2. Fluid which weeps from the burn surface contains protein in proportions approaching that of plasma, and the desirability of its conservation is obvious. Aluminum foil, by providing a physical barrier under adequate pressure, appears to diminish the surface weeping as compared with other forms of local therapy. In twenty-five of the fifty patients weighed dressings were applied which were

reweighed at ten days before and after drying, followed by determination of the content of water-soluble exudate. In twenty of these cases adequate occlusive pressure dressings were applied over the aluminum foil. In five cases voluminous dressings were deliberately applied with minimal or inadequate pressure. The results of this work are included in Table 1.

TABLE 1
ALUMINUM FOIL OCCLUSIVE PRESSURE DRESSINGS

Per Cent Burn Area, Degree of Depth	Initial Weight of Dressing Applied (Gm.)	Weight Gain in Ten Days "Wet Exudate" (Gm.)	Weight of Water-soluble Dry Exudate (Gm.)	Quotient Dry Exudate (Gm.) Burn Area (Per Cent)
15-II 5-III	446.0	274.0	25.5	1.3
5-II	182.1	15.2	7.0	1.4
3-II	220.8	2.3	2.3	0.8
20-II 10-III	968.4	151.4	77.4	2.9
5-II 3-III	216.8	306.8	22.8	2.9
8-II	242.4	56.1	17.9	2.3
4-(II) (III)	243.9	40.9	12.6	3.1
3-II	153.6	17.3	3.95	1.3
20-II 50-III	.....	.....	64.9	0.9
7-II	268.0	61.3	10.4	1.5
8-II	381.4	202.4	25.1	3.1
2-II	.....	.....	2.98	1.5
4-II	166.9	26.0	8.46	2.1
8-(II) (III)	285.4	118.4	12.0	1.5
6-II	369.2	95.8	14.9	2.5
26-II	663.3	299.2	70.0	2.7
8-II	.....	.....	8.04	1.0
7-(II) (III)	375.3	116.0	16.59	2.4
12-II	581.6	205.3	36.2	3.0
5-III 2-II	371.2	152.6	28.2	4.0
Aluminum Foil Occlusive Dressings with Inadequate Pressure				
3-II	147.0	30.8	20.86	6.9
5-II	629.0	110.5	22.24	4.5
5-II	408.6	76.6	19.8	4.0
4-II 10-III	375.4	74.5	25.44	5.1
3-(II) (III)	353.5	94.1	16.4	5.5

The rise in the value of the quotient (weight of dry exudate in Gm. divided by per cent of surface area burned) in those patients treated by inadequate pressure illustrated the value of occlusive pressure dressings in burn therapy. The value of pressure over aluminum foil was further emphasized in three of these patients by the observation of maceration and failure of dispersion of the exudate.

The weight of wet exudate in some cases, as noted in Table 1, was disproportionately large owing to marked contamination by urine, but this factor did not grossly influence the value of the quotient.

A similar series of weighed dressings and exudate extractions, using an ointment burn dressing instead of aluminum foil, will be required for comparison if the observation is to be substantiated that aluminum foil is of value in diminishing the surface weeping.

It has been considered that the maintenance of a dry dressing barrier offers a defense against bacterial invasion during the first ten days as compared with the portal of entry provided by a dressing which becomes soggy following some forms of local therapy.

The possibility has been considered that the reducing properties of aluminum foil may be an advantage in detoxifying, by reducing back, the abnormal oxidized products formed as a result of the burn.

ALUMINUM FOIL IN THE LATER TREATMENT OF BURNS

Aluminum foil was reapplied at the tenth day as well as subsequent dressings to the sloughing surface of a third degree burns. This area, as compared with other areas treated by sodium hypochlorite solution 1:12, was slow in reaching the stage at which grafting could be done. In two cases aluminum foil was applied to granulating areas awaiting grafting by multiple stages. No bleeding was encountered when the areas were uncovered. The granulations themselves appeared slightly paler than usual and were covered with a thin, glairy secretion. Grafts took well on these areas in both cases.

In two cases aluminum foil was applied as a dressing over the paraffin mesh used to fix fresh partial-thickness grafts. The results were satisfactory and the dressings were removed easily without trauma. The results of application of aluminum foil to two donor areas compared favorably with the standard scarlet R dressing.

TITANIUM DIOXIDE OINTMENT

Investigation of the use of titanium dioxide ointment as a local application for fresh thermal burns was initiated through the necessity of procuring a combined exposure cream and burn ointment. The formula for the ointment was obtained from a report[4] submitting its use as a means of allaying the pain of thermal burns. The ointment itself was made up on a special order and is a creamy white mixture consisting of six main ingredients:

	Per Cent
Titanium dioxide (TiO_2)	10
Wool fat	15
Vaseline	5
Lanette wax	10
Glycerine	25
Manucol	35
Drop of 0.1 per cent chlorocresol as preservative.	

Lanette Wax[5] is largely stearyl alcohol with 10 per cent partial phosphate stearyl and cetyl alcohols. Manucol is sodium or calcium alginate. Titanium dioxide itself is a highly insoluble stable substance found chiefly in ilmenite ore commercially but universially present in small amounts in the earth's crust and in various tissues of the body. In the ointment this ingredient gives protection against sunburn by virtue of its opacity.

Prior to the use of this ointment on a fresh burn the toxicity of titanium dioxide was in question while the other ingredients were considered innocuous. A survey of the literature revealed no report of toxic reaction to TiO_2 while Huggins[6] and others declared that it was found to be non-toxic despite large intravenous injections into experimental animals.

By reason of its known highly insoluble nature it was considered that ingestion by phagocytosis rather than absorption would be the mode of entry of titanium dioxide, if at all, into the body of a burn patient. Even the most sensitive chemical methods of determination[7] of TiO_2 were obviously not applicable to the necessarily small blood samples which could be obtained from children, and microscopic detection of titanium dioxide in the phagocytes of the peripheral blood of burn patients treated with the ointment was attempted instead. In order to recognize the substance an intravenous injection of a rabbit was carried out, and the particles were readily visualized using blood smears stained with Leishman's stain. The particles appeared singly and in clumps, chiefly in the cytoplasm of the polymorphonuclear leukocytes, but occasionally in the monocytes. Four and one-half months later this animal showed no gross or microscopic evidence of disease when autopsied and the titanium dioxide at this time was visualized in the fixed and wandering cells of the reticulo-endothelial system in the liver, spleen, lung and bone marrow. In the lung TiO_2 was evidently being eliminated from the body in the bronchial secretion in the process demonstrated by Irwin.[8]

In the clinical series of burn patients treated with titanium dioxide ointment, smears of capillary and venous blood were examined repeatedly without the discovery of any cell containing the particles. It was considered that phagocytosis of the particles at the burn surface was slight and if it did occur the phagocytes were not recovered from the blood before becoming fixed in the reticulo-endothelial system.

Influence of Titanium Dioxide Ointment on the Burn Surface. The ointment which was spread on nainsook was applied to a portion of the burn surface in six clinical cases and to the donor area from which a partial-thickness graft had been removed in one case. The usual scarlet R dressing was applied to the remainder of the donor area and vaseline gauze or aluminum foil supplemented the dressing of each burn.

No abnormal systemic reaction to the use of the ointment was noted, but the local result was disappointing. Although its use as an application for allaying the pain of thermal burns had been advanced,[4] 50 per cent of the burn patients in our series complained of pain localized to the area covered with the titanium dioxide ointment. This symptom began after a comfortable latent period of twenty-four hours or more and was a spontaneous complaint repeatedly accurate as to the area involved. Control dressings were consistently comfortable.

At the ten-day redressing three cases of superficial second degree burns were healing equally as well as the control in each case. The donor area, likewise, gave an equally good result. Two patients with deep second degree burns showed evidence of irritation. Healing of the areas which had been treated by titanium dioxide ointment eventually was completed by epithelization but was much retarded as com-

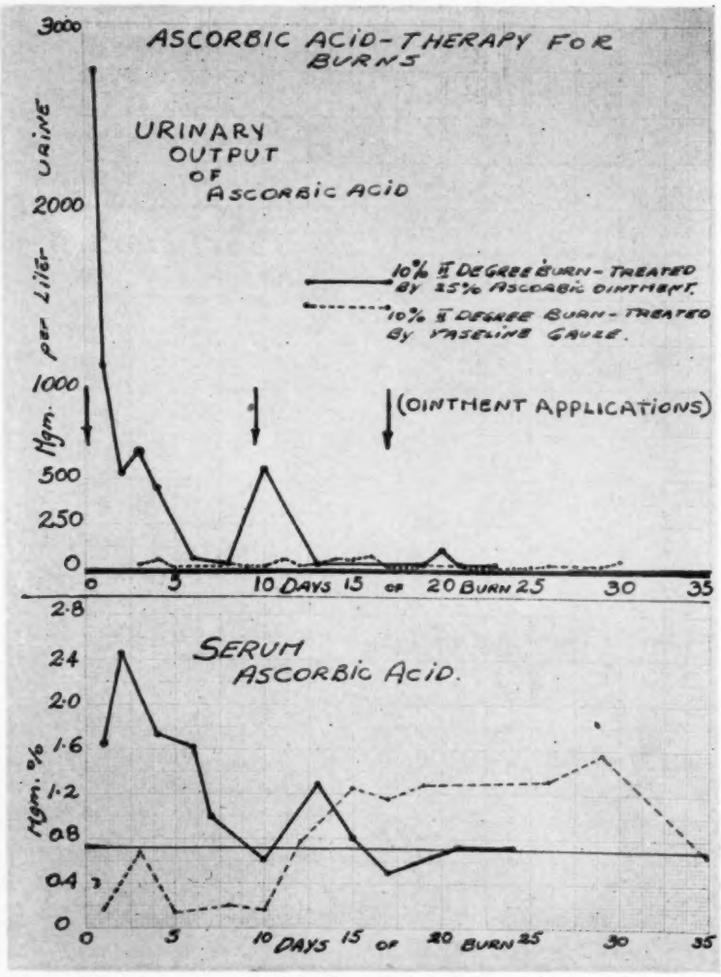

FIG. 2. The urinary output and blood levels of ascorbic acid from two patients burned to an almost similar area and depth. One of these was dressed with 25 per cent ascorbic acid ointment and the other with vaseline gauze.

pared with the control therapy. This was clearly demonstrated at three weeks in one of the cases in which a clear cut band of crust formation across the lumbar region, exactly coinciding with the area dressed with the ointment, was in sharp contrast to the cleanly healed burn above and below which had been treated with aluminum foil.

As well as delay in healing one final case demonstrated the possibility of the irritating factor being active in conversion of a deep second degree burn into a third degree area requiring grafting. Although indistinguishable from other areas initially, the area under titanium dioxide ointment at the tenth day showed evidence of irritation as compared with the remainder of the burn and a small central area eventually granulated and required a small partial-thickness graft.

Because vaseline gauze was used as well as aluminum foil to demonstrate the unfavorable comparable result, some factor other than maceration is believed to be responsible for the production of pain, the delay in healing and the damage to epithelial remnants.

ASCORBIC ACID THERAPY FOR BURNS

As Andreae and Browne[9] reported a very low ascorbic acid plasma level and marked reduction in the urinary output of the acid following burns the hypothesis was suggested that ascorbic acid, by virtue of its redox potential, might reduce and thereby detoxify abnormal oxidation products formed as a result of the burn. Were this hypothesis true the marked disappearance of ascorbic acid would be explained, and it was postulated that prevention of toxemia might be accomplished by

administration of ascorbic acid in quantities adequate to detoxify, by reducing back, the major portion of such substances. This portion of the work was carried out with the cooperation of Dr. K. F. Clute during 1946 to 1947.

Twenty burn patients were treated with massive doses of ascorbic acid. The therapy in some cases was confined to an ascorbic acid ointment with eucerin base while other patients were treated by dressings of a 5 or 10 per cent aqueous solution of ascorbic acid supplemented by oral therapy.

The low urinary output of ascorbic acid and the low plasma level were overcorrected to well above normal ranges within a few hours. Several Gm. of ascorbic acid were excreted in the urine in twenty-four hours, with concentrations of the acid in the urine as high as 10.4 mg./cc. In Figure 2 the ability of ascorbic acid ointment on the burn surface to raise the plasma level and urinary output is compared with a control case of equal body surface involvement in which vaseline gauze was applied and no ascorbic acid was administered except the usual amount added to the hospital diet. The great absorptive power of a burn surface is well illustrated.

Despite the rapid correction of ascorbic acid depletion, the general signs and symptoms in severe burn patients were not influenced to an appreciable degree. This opinion differs from that of Einhauser who, Harkins[10] relates, found vitamin C advantageous in prolonging the life of animals burned experimentally and later extended his observations to patients, with good results.

Ascorbic acid ointment has been found to be of value as a topical application to third degree areas from which slough is slow in separating under sodium hypochlorite solution 1:12. Speedy separation of slough has been noted following application of the ointment. The immediate production of pain was a consistent feature of the local application of ascorbic acid ointment or the aqueous solution to fresh burn surfaces. Undesirable general systemic reactions to the administration of massive doses of ascorbic acid were not encountered in this series of twenty patients.

Control Cases. In thirty-five burn patients treated by other than ascorbic acid applications the urinary output of reduced ascorbic acid was repeatedly determined from freshly voided specimens. Plasma levels of total ascorbic acid were followed in seven cases and single estimations were obtained in an additional four. The results of this work were consistent with the findings reported by Andreae and Browne.[9]

INFLUENCE OF THERMAL BURNS ON BLOOD GLUTATHIONE

Glutathione normally plays an enzymic rôle in aerobic intracellular oxidation, reduction in the body. The variation in blood levels following burns was studied as a result of the simultaneous interest in ascorbic acid metabolism, both glutathione and ascorbic acid being members of the redox system.

In the blood stream glutathione is present in the red blood cells only and is found throughout various body tissues as well. The reduced form (GSH) is a sulfhydryl tripeptide of glutamic acid, cysteine and glycine; the oxidized form (GSSG) observes and S-S linkage of two molecules, with the loss of one hydrogen from each sulfhydryl radical. The estimation of this substance in the venous blood of children was carried out by the iodometric titration method of Woodward and Fry.[11]

Venous blood samples were drawn from eight burn patients at daily or bidaily intervals throughout their period of hospitalization. One late burn patient who arrived at the hospital on the thirtieth day with a cleanly granulating burn surface and one normal adult were followed as controls. Serum ascorbic acid levels were determined on each specimen in order to investigate the possibility of a relationship between the changing levels of these two members of the redox system. Because the glutathione is contained within the red blood cells only and since the estimations were carried out on whole blood, red blood cell counts and hemoglobin estimations were carried out on each specimen of blood in order to correct for hemoconcentration as a result of the burn and hemodilution as a result of plasma therapy, each of which would impose an apparent variation in glutathione levels during the illness.

Results. Cicala[12] and Titone[13] individually reported an initial increase in glutathione in the blood following thermal burns. This increase may have been largely due to the influence of hemoconcentration on the glutathione determinations.

In our series of eight patients glutathione showed an irregular fluctuation within the

normal limits established by the determination of the glutathione content of the blood of twenty normal children. The two control patients showed a similar day-by-day fluctuation. Blood glutathione was not found to be influenced by thermal burns and no consistent relationship to the serum ascorbic acid levels was found, either during the stage of ascorbic acid depletion or following the rise of serum ascorbic acid to normal limits.

SUMMARY

1. Aluminum foil as a dry sterile initial covering for thermal burns under occlusive pressure dressings has been presented as a method of diminishing the maceration of a burn surface. The method appeared to influence favorably the local result by elimination of the use of ointments and by facilitating the dispersion of exudate to the periphery of the burn. No evidence of toxicity as a result of the treatment was found. The systemic reaction was, if anything, less obvious.

2. Titanium dioxide exposure cream as a burn ointment was considered to be irritating from the evidence of production of pain, delay in healing and possible destruction of epithelial remnants.

3. Massive doses of ascorbic acid administered to burn patients quickly corrected the state of ascorbic acid depletion, but the general systemic reaction to thermal burns was not found to be influenced by this form of treatment and the general signs of illness were marked in severe cases.

4. Blood glutathione levels were not found to be influenced by thermal burns within the limits of the method of determination employed and bore no consistent relationship to changes in serum ascorbic acid levels.

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DISCUSSION

Grover C. Penberthy (Detroit, Mich.): Local application of aluminum foil in a fresh burn is another contribution to the treatment of very serious lesions. Dr. Farmer and his associates are to be congratulated on their continued interest in trying to promote better treatment for the severely burned patient.

This appears to be an ideal local application. From the standpoint of acting as a covering of the burned area, no doubt relieving the patient of pain, pain being one of the disturbing and very annoying complications and aspects of the burn lesion, this use of aluminum is something that I think all of us will be interested in. He has shown by a comparative study of the various local applications that the aluminum foil has merit.

I would like to ask Dr. Farmer if he thinks there is antibacteriostatic or bacteriocidal action in the use of the aluminum? He reports the lesions as being fresh and pink at the end of ten days, in contrast to that type of lesion treated by dry gauze or by vaseline gauze. I recall many years ago as an intern in New York that we used a solution called aluminum acetate. I have not seen aluminum acetate used in many years but I recall vividly how that was used as an antiseptic solution in the treatment of infected wounds and as a substitute for boric acid or saline.

A. W. Farmer (closing): Thank you, Dr. Penberthy.

The only question Dr. Penberthy asked concerns the bactericidal action of aluminum. We know nothing about it. That entered our minds and further investigation will have to be done on the subject but I cannot give you any data on it at all.

HERNIATION OF FASCIAL FAT*

A CAUSE OF LOW BACK PAIN

DENMAN C. HUCHERSON, M.D. AND JOE R. GANDY, M.D.
Houston, Texas

IN 1945 Herz[3] described a condition causing low back pain which he attributed to painful fatty tumors of the back. He reported six cases, all in women, in which the removal of these fatty masses completely relieved the symptoms. A year earlier Copeman and Ackerman[1] reported ten cases (all British soldiers) in which fatty tumors were excised from the back, with striking relief. These authors also dissected fourteen backs and concluded that the palpable masses were herniations of fat through the fascia of the back. These latter two authors in 1947 reviewed their cases and reported an additional twenty-one.[3] They were still enthusiastic about the procedure and suggested that the herniations might occur elsewhere in the body. Since the publication of these papers, we have operated upon forty-two patients with painful palpable masses in the low back and we have corroborated the findings of Copeman and Ackerman to our satisfaction.

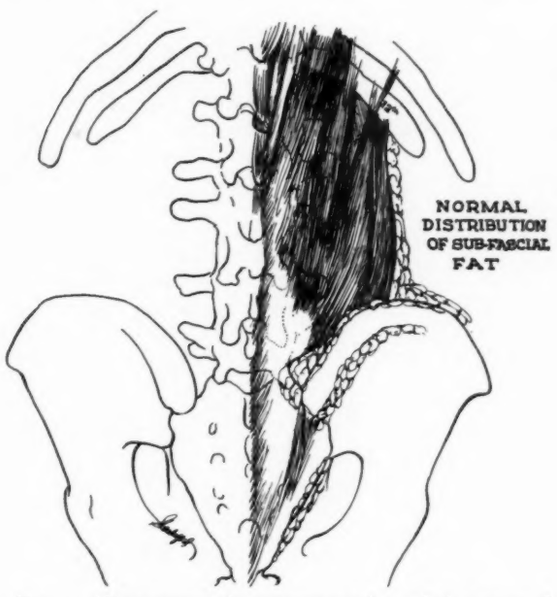

FIG. 1. Diagrammatic representation of the normal distribution of subfascial fat according to Copeman and Ackerman.

CLINICAL ASPECTS

All of our patients have complained of backache of varying degree and intensity which they were able to localize fairly well within a definite area. Frequently the pain was referred, being sciatic in distribution or radicular in character. Three patients complained of testicular pain. Palpation of the mass always caused the patient to wince involuntarily and most often the referred pain was reproduced or intensified by this pressure. These trigger points tend to occur in predictable sites which Copeman and Ackerman refer to as a "pain pattern." This pattern follows from above downward the lateral border of the sacrospinalis muscle from the costal margin to the crest of

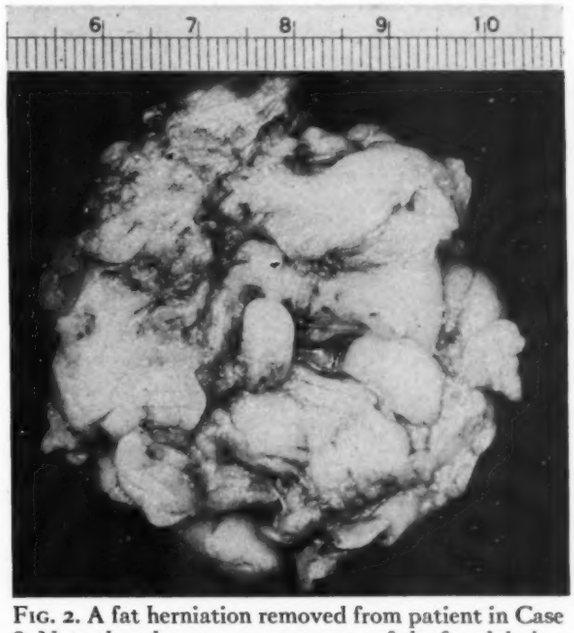

FIG. 2. A fat herniation removed from patient in Case 8. Note the edematous appearance of the fat globules. This section is larger than average but shows the typical appearance. The scale is in millimeters.

* From the Department of Orthopedic Surgery, Baylor University College of Medicine, and the Southern Pacific Hospital, Houston, Tex.

TABLE 1

Name	Age	Sex	Symptoms in Months	Location	Radiation	Comment	Result
1. D. A. T.	28	M	48	Iliac crest bilateral 2 in. from midline	To anterior abdominal wall	Complete relief	Excellent
2. H. G. B.	40	M	¼	Inferior to iliac crest, left	Sciatic to knee, left	Complete relief	Excellent
3. J. O. M.	40	M	18	2 nodules inferior iliac crest, right	To right hip	Complete relief	Excellent
4. J. H. H.	61	M	18	Superior crest ilium, left	To left testicle	Complete relief	Excellent
5. T. H. L.	49	M	60	Lateral to right posterior superior spine	To right thigh and right testicle	Complete relief	Excellent
6. R. J. G.	34	M	48	Superior to right posterior superior spine	To right testicle	No relief, later had laminectomy and spine fusion, without complete relief of symptoms	Failure
7. L. L. N.	55	M	48	Inferior to left iliac crest	Sciatic to knee, left	Complete relief	Excellent
8. G. E.	33	M	48	Inferior to right iliac crest	Lateral aspect of right thigh	Complete relief	Excellent
9. A. M. T.	47	F	54	Level 4th lumbar, bilateral	None	Pain not as noticeable but dull low back pain at times	Fair
10. D. R. W.	20	M	9	3 cm. lateral to right sacroiliac joint	To right knee	Complete relief	Excellent
11. M. M. H.	27	F	¼	Right sacroiliac joint	To front of abdomen	Complete relief	Excellent
12. H. A. S.	55	M	12	Inferior to right iliac crest	Sciatic to right calf	Complete relief	Excellent
13. R. A. S.	53	M	1	Inferior to left iliac crest	Lateral and anterior surface of left thigh and knee	Complete relief	Excellent
14. G. D. N.	40	M	36	Inferior to right iliac crest	Lateral surface, right thigh	Complete relief	Excellent
15. L. C.	45	M	6	Bilateral, lateral to posterior superior spine	None	Patient a physician; after one year stated he was 80% improved	Good
16. N. C.	30	M	3	Lateral posterior superior spine, left	Sciatic to left knee	Complete relief	Excellent
17. D. W. W.	55	F	6	Lateral posterior superior spine, left	None	Complete relief	Excellent
18. J. R. B.	20	F	5	Lateral posterior superior spine	None	Complete relief	Excellent
19. H. M. O.	40	M	6	Lateral posterior superior spine, right	Sciatic	Had previous laminectomy without relief; returned to heavy work after fat pad removed	Excellent
20. M. W. U.	50	M	5	Inferior posterior superior spine	To left thigh	Fat pad not identified at operation; fat in region excised; mild backache still present but no radiation	Fair
21. L. D. J.	40	M	¾	Inferior iliac crest, bilateral	None	Complete relief	Excellent
22. M. B.	38	M	2	Over crest ilium, left	Sciatic, left leg	Complete relief	Excellent

TABLE 1 (*Continued*)

Name	Age	Sex	Symptoms in Months	Location	Radiation	Comment	Result
23. F. B. A.	43	M	1	Lateral border sacrospinalis, left	None	Complete relief	Excellent
24. C. J. P.	37	M	24	Inferior iliac crest, right	Numbness right leg	Complete relief	Excellent
25. J. M. C.	43	M	12	Iliac crest, right	Sciatic to right knee	Complete relief	Excellent
26. J. B.	37	M	6	Inferior iliac crest, bilateral	None	Mild pain 2 mo. after surgery, followed by complete relief	Good
27. L. D. W.	47	M	½	Inferior iliac crest, right	None	Complete relief	Excellent
28. U. B.	57	M	1	Superior to posterior superior spine, left	None	No preoperative x-ray; no relief of symptoms; postoperative x-ray revealed metastatic lesion of 5th lumbar vertebra; died 1 mo. later	Failure
29. W. L.	56	M	2	Inferior to posterior superior spine, right	None	Complete relief	Excellent
30. H. H. N.	53	M	6	Inferior to iliac crest, right	To right thigh	Severe pain and backache relieved; still has occasional mild backache	Good
31. L. J. L.	43	M	6	Superior posterior superior spine, right	Sciatic radiation, right	Complete relief	Excellent
32. S. D. C.	18	M	1	Inferior iliac crest, right	To anterior surface, right thigh	Complete relief	Excellent

the ilium. In the gluteal region the points are found about the posterior superior spine, along the crest of the ilium and about 5 cm. below it. They are also found along the line of the sacroiliac junction but are not commonly found elsewhere in the buttock. These points correspond to the normal distribution of fat beneath the posterior fascia. (Fig. 1.)

Injection of the painful nodules with 1 per cent novocain will afford temporary relief and should always be carried out as a diagnostic procedure.

We have not seen any sensory changes, reflex phenomena or muscular weakness associated with this condition.

CLINICAL PATHOLOGY

Copeman and Ackerman classify these fat hernias into three anatomic types: the pedunculated, non-pedunculated and foraminal. The names are self-explanatory except for the last mentioned. The cutaneous branches of the posterior rami of the last three lumbar nerves pierce the deep fascia through definite foramina and fat globules may protrude through these foramina producing typical herniations.

Microscopic examination of the tissue from all the cases here reported was done by the Pathology Department of Baylor University College of Medicine. All of the sections consisted entirely of normal adipose tissue. None showed evidence of edema or inflammatory reaction. Nerve tissue has been observed in some of the sections but the finding has not been consistent. (Fig. 2.)

OPERATIVE TECHNIC

The skin is infiltrated with 1 per cent novocain in a transverse line over the nodule. After cutting through the skin and superficial fascia, the mass will usually pop into the wound and it will as a rule be larger than was expected from preoperative examination. The herniation is removed by blunt and sharp dissection; and if there is any doubt as to the limits of the mass, the surrounding fat should be freely

removed. Bleeding should be meticulously controlled as formation of hematomas will delay the patient's convalescence and mask the result. The wound is closed with interrupted sutures and a rubber tissue drain is left in place for forty-eight hours.

Only a local anesthetic should be used for the patient's pain perception is valuable in locating the herniation. In two patients who were given a general anesthetic the masses could not be identified.

CASE REPORTS

In Table 1 thirty-two cases are presented. All the cases in this series have been followed from six months to two years. Ten cases were excluded from this report as they have been followed less than six months. In these ten, however, the results have so far been excellent.

SUMMARY AND CONCLUSIONS

We have briefly reviewed the work of Herz, Copeman and Ackerman and presented thirty-two cases operated upon by us.

In the clinical cases described in this paper twenty-eight were male and four were female. The patients varied in age from eighteen to 61 years. There was no characteristic body type but none was extremely obese. In all but seven of our cases we have considered the results excellent. Five of these seven patients believed that they had experienced enough relief to warrant the operative procedure. One failure was due to inadequate work-up; the other failure we cannot explain.

We believe that herniation of fascial fat is one more definite cause for back pain that has been added to our knowledge of this perplexing problem.

It is hoped that this paper will stimulate interest in this condition, but we would like to caution against overenthusiasm so that this procedure may not fall into the disrepute of some of the other operations employed for the relief of certain types of low back pain.

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DISCUSSION

Charles Francis Wood (Louisville, Ky.): I must confess that I have never recognized this condition, if indeed I have ever seen it. Certainly it is an interesting condition; and I believe that if it does add one more weapon to our armamentarium for the treatment of lame low back with or without radiation, it will be a good thing.

I have been rather impressed with the localization of most of these masses in the region of the posterosuperior iliac spine. I worked with Dr. Clarence Heyman of Cleveland when he was doing his work on his posterior fasciotomy, and it seems to me that the localization of pain in these two conditions is just about the same.

Furthermore, I like these authors to be definitely commended for cautioning against overenthusiasm for this or any other single procedure for the relief of these patients. I do not think we can treat them until we diagnose them. If we examine them carefully and diagnose them accurately, I think we will find many procedures which will relieve some cases if they are properly selected.

Frederick Reichert (San Francisco, Calif.): I would like to point out that the essayist mentioned referred pain, and I am curious as to why this referred pain should come from this little fat pad.

He mentioned rightly that he now has been using procaine in his injections. We have used the fine needle and accurately located the trigger spot, and with 2 per cent procaine (not 1 or 1½ per cent but, for some reason, 2 per cent which is much more specific) we have been able to relieve them permanently of their pain by injecting these trigger spots.

It is curious, too, that the trigger pains may be between the spinous processes, L-4, L-5 and S-1. There seem to be no blood vessels there, but there certainly are sympathetic fibers. I think this referred pain is due to irritation of the sympathetics that are in this fat pad that you cannot stain when you are studying your sections. If you will accurately attempt to find these trigger spots and inject them with 2 per cent procaine—and, more important, to hold and massage these areas afterward for ten or fifteen minutes so that there is no evidence of hemorrhage which would make the patient worse, you may be able to save him from an operation.

Wilbert Hersman McGaw (Cleveland, Ohio): We all know that there are many causes of backache; and if we can place one finger accurately on one cause, I think it is a real contribution to the whole problem of back pain. Dr. Hucherson has approached this subject in a very scientific manner. Being from Cleveland, we have heard about Dr. Herz's work. I have also had the privilege of seeing some of his patients before and after surgery and I

am sure that many of them have had relief. However, I do believe that a complete study of any chronic back case is indicated.

I have used procaine injection in these painful areas and have noticed that at times a procaine wheal is as effective in giving relief as trying to infiltrate the base of the tender area.

I would like to ask Dr. Hucherson whether or not he has operated on any patients without first using procaine, or if he believes that procaine injection is an adequate test or indication as to the success of surgery? I would also like to ask him if he believes that these fatty masses arise from under the deep fascia? I was not sure whether or not he goes through the deep fascia to relieve the hernial opening if there is one.

DENMAN C. HUCHERSON (closing): In reply to the question concerning injection of these painful nodules I would like to emphasize that we customarily inject them all as we not only consider it a diagnostic procedure but also believe that a great many patients are entirely relieved of their symptoms by injection. In our clinic where the majority of these injections have been done, we have been unable to follow the cases with sufficient efficiency to allow us to arrive at any reasonably accurate estimate of those cured by injection. It would be my estimate that about only one case in four requires surgery. We usually recommend removal of the herniation if the pain recurs after about the third injection.

Dr. Herz, who was to discuss this paper but could not be present today, has written me that he has a series of 229 of these cases. He has carried out injection routinely and has found it necessary to operate upon only sixty-seven. I believe this ratio will be found to be about normal.

We are asked, in relation to the fascia, where these masses are found. They are found beneath the subcutaneous fat of the back. The masses arise from the potential space formed by the superficial and deep fascia of the back.

As far as the rent in the fascia is concerned, we do not attempt to close it but rather enlarge it and remove all the fat in the area.

We have no explanation for the mechanism of the pain. We have been very pleased with, what we consider, the very excellent results in this series. I think it most important to mention that most of these patients we reported on today were operated upon at the Southern Pacific Hospital at Houston which is a railroad hospital. These men are all industrial cases and the compensation angle is involved. All of the patients classified as having excellent results have returned to full duty, many of them to section labor.

AMPUTATION OF EXTREMITIES

S. A. Swenson, Jr., m.d. (*by invitation*) and J. Dewey Bisgard, m.d.
Omaha, Nebraska

AMPUTATIONS of extremities are becoming increasingly more frequent with the advent of more modern mechanized living. During the past war about 17,000 individuals in the service of the United States underwent amputations of one or more extremities. Vital statistics reveal the fact that each year in the United States over 20,000 amputations of the extremities are performed in the civilian population. There is an increasing need for closer relationship between the surgeon, physiotherapist and the limb fitter. Experience gained in Army Amputation Centers during the past war has resulted in a better understanding of the physiology of the use of extremities, the technic to produce the most satisfactory stump and the proper fitting of improved prosthetic appliance and understanding of the problems of the amputee in general.

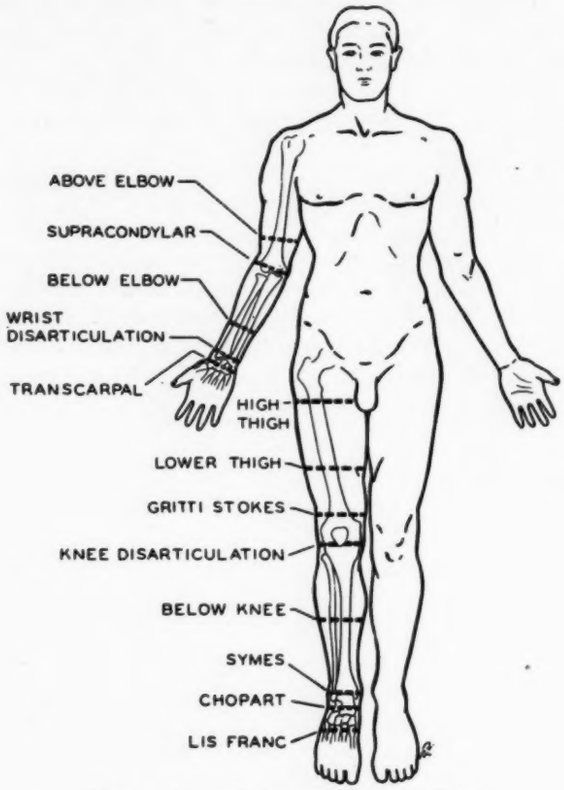


Fig. 1. Amputations; optimum levels.

In civilian life, indications for amputations may be divided into four categories: trauma, circulatory diseases, neoplasms and congenital or acquired extremity deformities in which better function is possible with an artificial appliance. At present perhaps circulatory diseases are responsible for the greater percentage of amputations in civilian life; but with the rapid advance of mechanized living, especially in the middle western rural population, trauma is becoming a more prominent factor. Great progress has been made in fluid balance and anesthesia which has resulted in more radical surgical procedures for the removal of neoplasms of the extremities with increasing success in cures of long duration, and modern prostheses have been devised which aid these individuals to return to a useful life. Circulatory disease of sufficient severity to result in amputation is usually found in the age group over forty-five to fifty years. Most of the amputees of this last war were in the prime of life and growth, and the difference between these two age groups must be considered in the discussion of site of amputation, length of skin flaps and the fitting, wearing and education in the use of the prosthesis.

The primary aim of any amputation is first to eradicate the abnormal condition for which the amputation is indicated and, second, to produce an extremity stump which will be of greatest functional value when applied to the proper prosthesis. General points of importance include optimal levels of amputation, the shape of the stump (Fig. 1), proper placement of the scar, treatment of bone ends and treatment of nerves and other soft tissue structures.

Little time need be spent in discussion of proper or optimal levels of amputations. These have been well established by the vast experience gained in military and civil practice. There are, however, a few changing concepts which have been the result of recent progress in the development of prosthetic appliances.

UPPER EXTREMITY

Amputations below the Elbow. Until the past war it was generally accepted that any

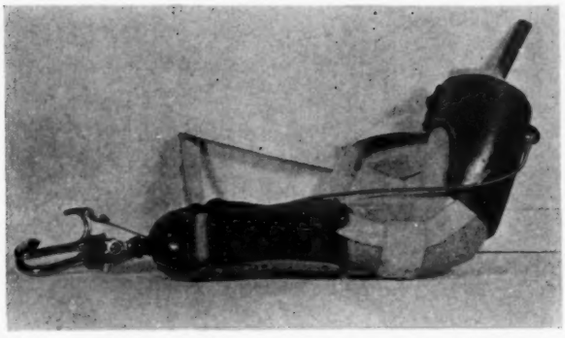


FIG. 2. Prosthesis for carpal-metacarpal disarticulation; developed by Comdr. T. J. Canty, Mare Island, California.

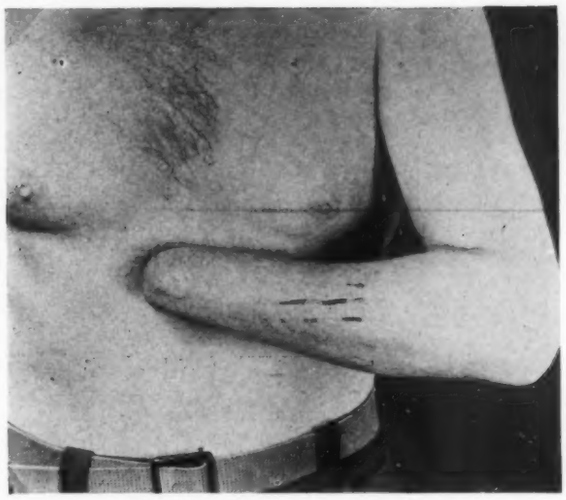


FIG. 3. Transcarpal amputation.

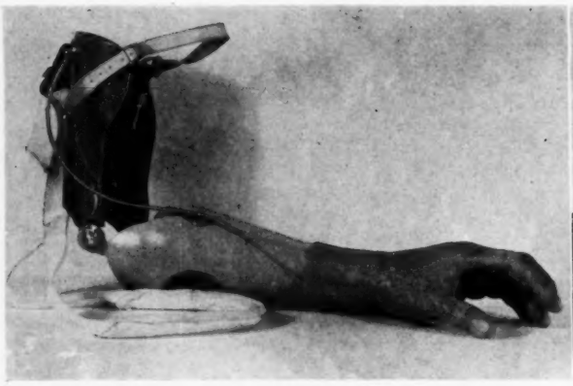
length beyond a 7 inch level in a forearm amputation was useless. Lately prostheses such as the one developed by Commander T. J. Canty at Mare Island Naval Hospital, California, have resulted in a definite indication for preservation of the carpal bones if possible. (Fig. 2.) This type of amputation, when applied to this prosthesis, results in a stump which retains all normal wrist functions, i.e., pronation and supination of the forearm, dorsi and palmar flexion of the wrist joint. It is not difficult to see that such a combination will give the amputee an extremity which will be of much greater use to him and will return him to a much more useful place in society.

Wrist disarticulations or even transcarpal amputations have been performed and have resulted in increased function when applied to proper prostheses. Previously it was difficult to fit such a stump so that the artificial hand or hook did not give the appearance of a longer forearm than the normal one. The wrist disarticulation, transcarpal or carpal-metacarpal stumps have proven particularly effective in patients with bilateral upper extremity amputations through increased function and applicability of the improved prosthesis. (Fig. 3.) The prosthesis usually does not extend above the elbow and is made of molded leather, closely fitting the contour of the stump. A bulbous bony stump such as results from a wrist disarticulation is then an advantage to keep the molded leather prosthesis from slipping off the stump.

A great deal has been written about cineplastic procedures for increased function in amputation stumps. A forearm amputation is probably the only one in which this technical refinement seems applicable. It must be remembered that no matter how strong a muscle loop may be range of motion is limited. If range of motion is increased mechanically in the prosthesis, power must be sacrificed. Needless to say, this type of prosthesis is practically useless for any heavy work and therefore its application is limited to a relatively small number of amputees, particularly in the rural areas of the middle west.

There have been several recent improvements in technic of operation and development of prostheses for short, below-elbow stumps. The great flexor of the elbow, the biceps muscle, inserts on the radial tuberosity which in an average sized individual is about 1 to 1½ inches distal to the radial head. If the insertion of the biceps tendon is left in place, a 2 or 3 inch forearm stump is practically useless as a motor for a forearm prosthesis. A simple procedure in which the biceps tendon is transplanted from the radial tuberosity to the radial head or even the coronoid process of the ulna increases the functional length of the stump but, of course, decreases power of leverage and range of motion. A multiple action elbow joint has been developed for this type of stump in which, although the elbow can be flexed only to about 90 degrees, the elbow of the prosthesis will flex to the desired 30 degrees so that the mouth may be reached.

There has been a great deal of research and progress made in the development of upper extremity prostheses. Several ingenious mechanical hands have been devised but the usual difficulty is presented. With increased function there is a directly proportionate increase in mechanical complexity. Some types of mechan-



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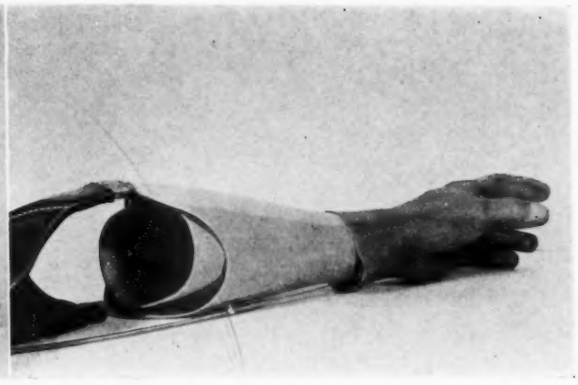

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FIG. 4. Forearm prosthesis with Northrup cable control and latex rubber hand.
FIG. 5. Forearm prosthesis with Northrup wrist control. Note position of stump socket in relation to supination of the hand.

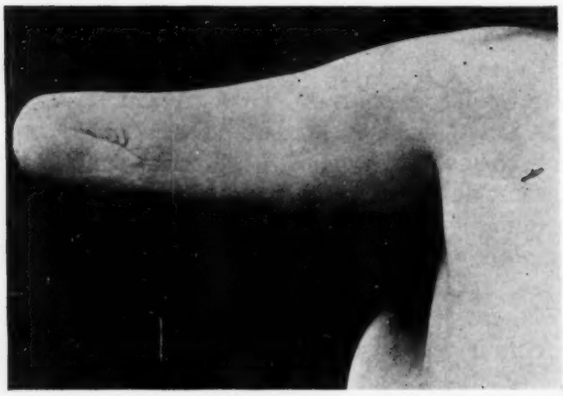

FIG. 6. Elbow disarticualtion.

FIG. 7. Above elbow prosthesis with the Fitch elbow joint.

ical hands would require the services of a fine watchmaker for repairs. Again it should be emphasized that the most efficient prosthestic appliances are the most simple in mechanical construction, and that an amputee must be able to get repairs for his prosthesis without sending it away for a long period of time during which he will be deprived of its use. A simple remedy, of course, is a spare limb but not every amputee is able to provide himself with such insurance.

Two of the finest developments in upper extremity prostheses which came out during the past war were the Northrup wrist joint and the Fitch elbow joint. The Northrup wrist joint provides the motions of pronation and supination with the use of the forearm stump as the motor mechanism. (Figs. 4 and 5.) The stump fits into a molded plastic cup which is attached to a mechanism which amplifies its motion to the hook or artificial hand in a ratio of about 1 to 3. Thus, if only 30 degrees rotation is possible between the bones of the stump, 90 degrees rotation is produced in the external appliance. This is extremely useful in fine motions of the upper extremity, well illustrated by drinking from a cup. If there is no pronation or supination in the wrist, all tipping motion must be transmitted through the elbow, shoulder and head.

Amputations above the Elbow. Elbow disarticulations were tried without too much success. An attempt was made to utilize the epicondylar flare of the humerus to produce a bulbous bony stump to which a molded leather cuff could be applied. (Fig. 6.) If practical, this would eliminate the cumbersome shoulder harness necessary to keep an above-elbow prosthesis from slipping off. In successful cases

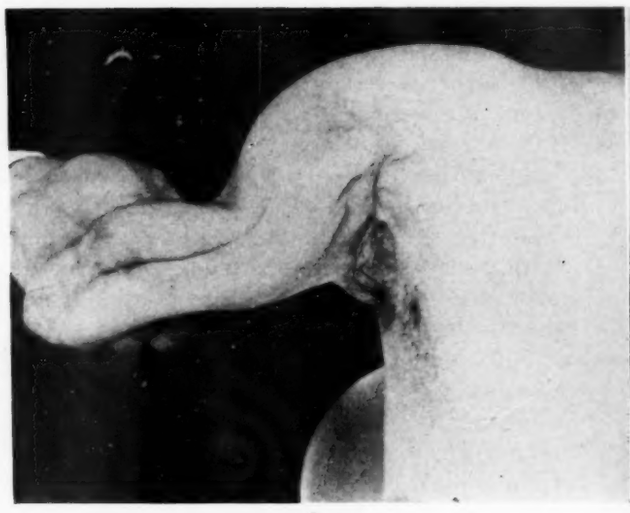

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FIG. 8. Short humerus stump with redundant soft tissue.
FIG. 9. Intramedullary fibular graft to lengthen short humerus stump.

it also provided stability in active motion and rotation of the humerus and the prosthesis. The main difficulty was in perfecting an elbow joint that could be locked in different positions of flexion and extension without making the upper arm part of the prosthesis too long.

The Fitch elbow is the only one to my knowledge that provides active control of flexion and extension. (Fig. 7.) It is controlled by antagonistic metal cables from opposite shoulder loops or anchors on the shoulder harness through the pulley-like mechanism illustrated. The only objection to this prosthesis was the lack of a lock for any set position, but this has probably been added since I last saw it.

Short humerus stumps are again a problem of insufficient length to provide adequate motor power for a prosthesis. Various plastic procedures, such as Z-plasty on the axillary folds and cutting of pectoralis and latissimus dorsi muscles, have been done with considerable success. Several cases have been recorded in which intramedullary grafts of fibula have been applied to short humerus stumps with skin. (Figs. 8, 9 and 10.) These have been successful, of course, only when there was adequate blood supply in the soft tissues to provide vascularization of the bone graft.

If at all possible, it is best to leave the head of the humerus in place on the glenoid fossa. This will result in a more rounded shoulder; and although most prostheses for amputations this high have only cosmetic value, it provides a stump which will fill out the shoulder of a coat without any appliance.

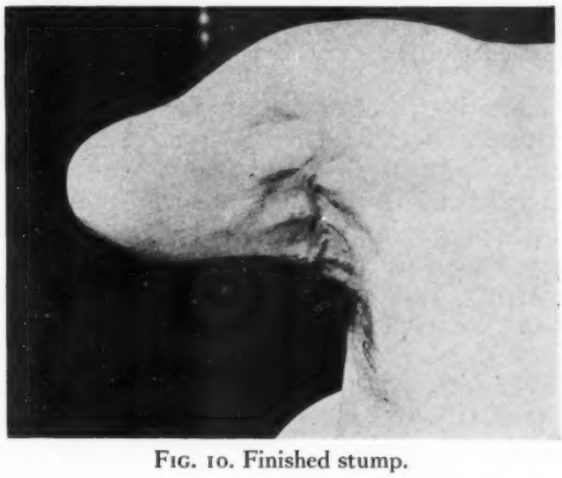

FIG. 10. Finished stump.

Prostheses have been devised for interscapulothoracic amputations but again these have little or no functional application and have only cosmetic value.

LOWER EXTREMITY

Amputations through the Foot. The most important requirement in amputations through the foot is an adequate plantar skin flap. A dorsal scar, placed where it is least subject to trauma, is an absolute necessity for a successful weight-bearing stump before anything else is considered. Phalangeal diarticulations, Lis Franc, Chopart, Pirogoff and, of course, the Syme amputations all fall into this category.

There have been few technical advances in amputations through the foot except for some minor refinements. In the shorter hind-foot

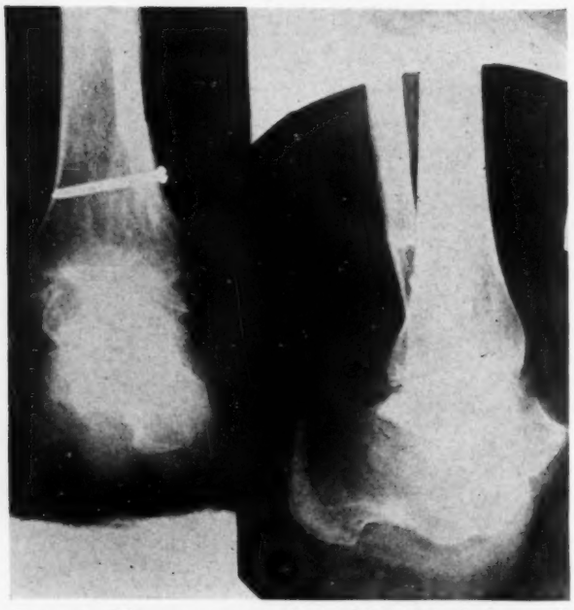

FIG. 11. Chopart amputation with ankle fusion and Gallie subastragalar stabilization.

amputations, such as the Chopart or Lis Franc, attempts have been made to stabilize the distal stump with tendon transplants or fusions. Actual bony fusion eliminates any motion in the joint, producing a club-like extremity, but is still the only adequate method for the prevention of everted equinus deformities in these stumps. Partial foot amputations are generally unsatisfactory and are difficult to fit but may be indicated in selected cases. (Fig. 11.) Figure 11 is the case of a man who suffered a traumatic amputation of the fore foot but as a bronco-buster in a rodeo desired to retain as much length as possible. Bony and soft tissue structures remaining permitted only a Chopart type amputation; therefore, to give him a stable stump an arthrodesis was done in the ankle joint and the subastragalar joint was stabilized by a Gallie type peg graft.

The Syme Amputation. The Syme amputation continues to grow in favor, particularly with the recent progress in the perfection of an adequate prosthesis for this type of stump. There is one very important point to be stressed in the technic of operation. It must be remembered that the shaft of the tibia is not at right angles to its weight-bearing surface; and when the malleoli are removed, the saw-line must be at right angles to the true perpendicular instead of at right angles to the shaft of the tibia. Shifting of the heel-pad and so-called spurs in Syme amputations is merely a result of inaccurate judging of the angle of weight-bearing.

Prostheses have now been developed for Syme stumps which should overrule most of the objections to this type of amputation. (Fig. 12.) This lightweight, laminated plastic prosthesis, developed by the U. S. Naval Hospital at Mare Island, California, is lined with the new unicellular sponge rubber and has complete ankle motion, including dorsi and plantar flexion, eversion and inversion.

Amputations below the Knee. It is universally accepted that the best amputation for anything below the knee is in the mid-calf region 5 to 7 inches distal to the plateau of the tibia. This stump can be fitted with the standard type of prosthesis that is so simple that repairs can be made in any local hardware or blacksmith shop. Variations in the prosthesis such as padded sockets, slip-sockets or absence of the thigh lacer may be supplied to selected cases.

Short stumps below the knee often present problems in surgical technic and fitting. It is usually advisable to remove the entire fibula in any stump of 3 inches or less. The interosseous membrane between the tibia and fibula is absent above this level to allow passage for the anterior tibial and peroneal vessels. If the fibula is left in place, the pull of the tendon of the biceps femoris is sufficient to rotate and abduct the fibular stump externally to such a degree that fitting with proper weight-bearing areas is impossible.

A difficulty in fitting short below-knee stumps is the lack of sufficient length so that the stump will remain in the socket. The hamstring tendons of the thigh have a comparatively low insertion on the tibia and fibula, respectively, and may be cut away, reinserted at a higher point or allowed to retract. The motion of active extension is certainly the most important in walking and locking the knee joint. Gravity, the weight of the prosthesis plus the flexor action of the gastrocnemius muscles provide sufficient motion so that walking is carried out normally.

If because of injury to the knee joint surfaces weight-bearing on the joint is undesirable and yet knee motion is possible, prostheses have been devised whereby weight-bearing is placed on the ischial tuberosity through a rigid thigh-piece. Normal knee motion is thus maintained with the tibial stump as the motor for the

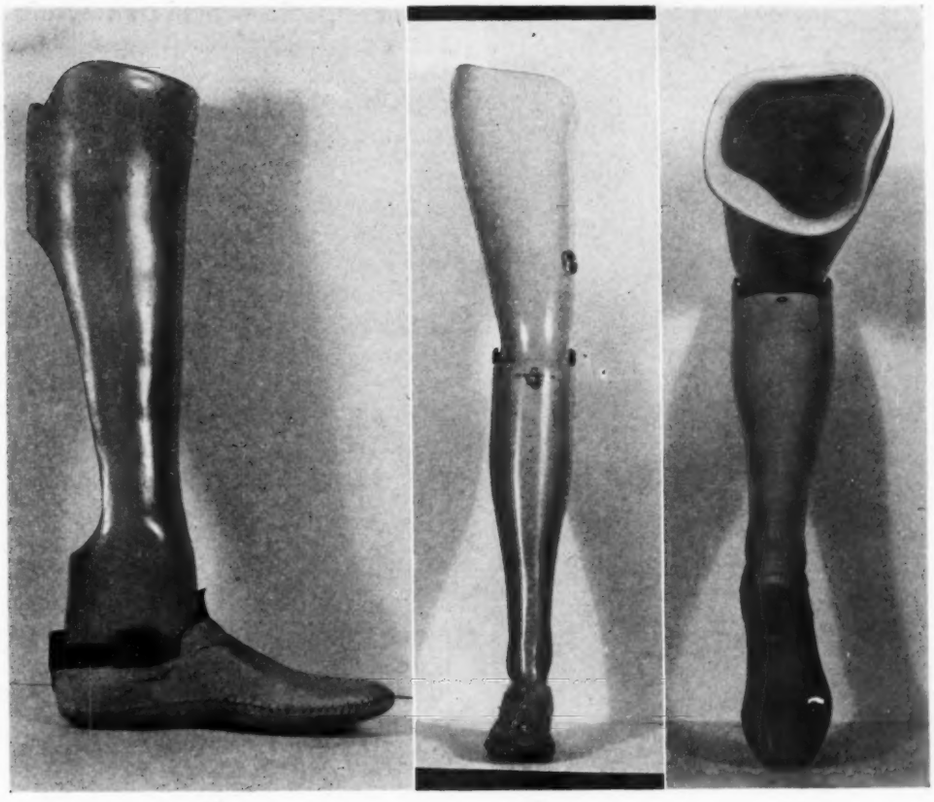

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FIG. 12. Syme prosthesis (courtesy U. S. Naval Hospital, Mare Island, California).
FIG. 13. Suction socket above knee prosthesis (courtesy U. S. Naval Hospital, Mare Island, California).
FIG. 14. End view of thigh piece, suction socket.

prosthesis below the knee, without weight-bearing on the injured joint. Platform prostheses with a free-swinging shank have been made for short, flexed below-knee stumps in such a manner that weight is borne on the bent knee.

Amputations above the Knee. In any amputation above the knee the problem of maintaining the prosthesis on the stump is of prime importance. The standard methods of attachment, such as the heavy articulated pelvic belt or the shoulder harness, are cumbersome and not entirely satisfactory. Variations in the type of stump will sometimes allow fitting of appliances which are quite stable without these disadvantages.

Knee disarticulations, with or without the removal of the patella, present a stump with sufficient bulbous flare in the femoral condyles that a molded leather lacer corset may be constructed to fit tightly enough that no other suspension support is necessary to keep the artificial limb in place. As a result of the findings of the Army Surgeon Generals' European Commission on Amputations and Artificial Limbs, the "suction-socket" prosthesis is rapidly gaining in favor in this country. Figures 13 and 14 illustrate this principle in an above-knee prosthesis. A more fleshy stump with active motion in the thigh muscles is desirable for this type of appliance, as direct contact between the skin and the socket is required for complete sealing and maintenance of sufficient negative pressure to hold the limb on the stump.

End-bearing stumps, such as the Gritti-Stokes', tendoplastic or Callander type amputations are done according to the likes or dislikes of the surgeon. The most important technical point is the angle of the weight-bearing surface as in the Syme amputation. The shaft of the femur is not perpendicular to the weight-bearing surface and the saw-line should not be at right angles to the shaft of the femur. No radical changes have been made in appliances for these amputations.

FIG. 15. Anterior view, tilting-table prosthesis.

The stump of amputations above the supracondylar, Gritti-Stokes levels should not be longer than 3 inches above the knee joint. Anything longer than this level not intended for weight-bearing makes it necessary to extend the thigh piece to include the artificial knee joint, shortening the shank and thus placing the artificial knee joint lower than the normal joint. The average femur measures 17 inches from the greater trochanter to the knee joint. Length beyond 12 inches is considered superfluous in any non-weight-bearing stump above the knee.

Improvements have been made in prostheses for amputations above knee stumps as short as 2 inches measured from the crotch. Thinner stumps are preferable. The anterior surface of the thigh piece is built high into the groin to prevent the stump from slipping out of the socket but the leg is quite uncomfortable in a sitting position.

When possible the head, neck and greater trochanter of the femur should be left in place to conserve the normal contour of the buttock and the pelvis. If the femur stump is too short to be of use as a motor mechanism, a tilting table prosthesis may be applied. (Fig. 15.)

SUMMARY

Anyone who had the opportunity to serve in a military amputation center during the past war would be impressed by the lack of adequate coordination in civil life between the surgeon, the physiotherapist and the limb fitter. Usually the surgeon performs the amputation and with the healing of the operative scar considers his job done. From that time on its the responsibility of the patient, with instruction from no one, to condition and shrink the stump in preparation for fitting. The patient is left to his own devices to search out a limb fitter who, depending on the equipment in his shop, will supply the type of artificial limb which is the most profitable for him to make. Upon receiving his prosthesis the patient again has nothing but heresay and perhaps the advice of a neighboring amputee to rely upon for instruction in the use of his prosthesis.

Every surgeon doing amputations should have at least some idea of the problems which confront the amputee. It is surprising how few people know even the fundamentals of using crutches properly. Physiotherapy with special exercises to re-develop the muscles to be used in the function of the artificial limb is extremely important. It is not difficult to understand that these muscles should be even stronger than those in use in the normal limb.

The shape and length of the stump and its application to the most desirable prosthesis should be of prime importance at the time of amputation. The surgeon should be well acquainted with recent developments in artificial appliances and their fitting to provide the patient with as nearly perfect a combination as possible.

DISCUSSION

J. DEWEY BISGARD (Omaha, Neb.): I asked Dr. Swenson, who has been associated with me in practice, to present this material for two reasons: First, he served for over two years in an amputation center and during his period of service gained a very unusual experience and can speak with considerable authority. Secondly, I believe, as he has stressed, that in civilian life the postoperative management of amputees, namely, the proper fitting, management and education in the use of

prostheses, is dealt with very inadequately. I think most of us through lack of knowledge, experience or interest delegate this important responsibility to a layman who has no background of physiology or anatomy necessary for the proper use of these prosthetic devices.

I have seen Dr. Swenson work with a few amputees who have been so handled, and by some simple alterations in the prosthetic devices or even a little education in how to swing the leg he has improved their function and made them far more comfortable. For example, I have seen him show people how to walk upstairs as one would normally rather than go up one foot at a time sideways.

I was glad to hear Dr. Swenson stress the conservation of as much of the extremity as possible. Now that we have antibiotics, improved methods, newer vasodilatory drugs and chemical and surgical sympathectomies, the old dictum of amputations above the knee in peripheral vascular disease no longer holds and is no longer good surgery in some cases.

I have a few cases (as many of you have) who have had transmetatarsal amputations for diabetic gangrene of the toes, have gone ahead and healed primarily without any difficulty and have been spared the necessity of getting a prosthetic device for many months or years.

AUGUSTUS THORNDIKE (Boston, Mass.): Your new President, Dr. Magnuson, has inveigled me into taking on a job with him concerning the research into newer prosthetic developments. Although there is little to report at this meeting, I believe that within twelve months we will be able to give you some proven information. It is only fair to say that these new developments are still on field test. I will go over a few of them if you understand that I am not saying they are perfected.

As Dr. Swenson says, it is important that we surgeons become acquainted with the fitting and training of our patients in the use of these prostheses. We must see our patients through the entire process. I think our Army program in our amputee centers is the first of its kind whereby we really developed a training procedure for the arm amputees so that in a week's time the patient could go out with his prosthesis and within six or eight weeks the leg amputee had even learned how to dance. We found that the use of music, as far as part of the leg amputee's training was concerned, developed a rhythm in his gait that he could not attain until he learned to dance. His balance and his rhythm were developed with the aid of a record player and a dancing partner.

The lower extremity suction socket you have seen. Within two months it will be on 800 wearers and we believe that is a sufficient group to give it a good field test. It is not ideal for all above-knee amputees, but a large majority of them who have worn them up to now claim that for the first time they feel as if their prosthesis were part of themselves. I have seen the suction socket on one above-elbow amputee and he particularly was pleased that it belonged to his body and no longer was hanging loose.

One of the major problems in the upper extremity prosthesis is that it pulls away from the stump and the patient feels it does not belong to him. If we can develop a suction socket there, I am sure we will get a more utilitarian prosthesis.

There are two types of hydraulic knees now under test, the Catranis hydraulic utility leg which will fit into any standard leg and be inserted into any artificial limb made. It weighs approximately 1½ pounds and depends upon a pressure pad against the rectus-femoris and sartorius attachment for its mechanism function. Together with the suction socket we have thirteen such cases on field test today.

The Northrup Vane type hydraulic knee works on a release mechanism that depends upon heel contact with the ground. To my mind this is not as smoothly a functioning development as the Catranis knee at the moment.

The Mare Island naval program has developed a soft socket for below-knee amputees. I believe this is a good development.

In the upper extremity there is a great question as to how valuable cineplastic procedures are going to be. I have seen tunnels in triceps, biceps, the pectorals and the pilot wearers who are developing this for us. All believe that unless the muscle tunnel is built on the anterior surface where they can keep it clean and see it themselves (the triceps they cannot clean and are not happy about that location), will not be able to care for it properly.

Many of us were acquainted with the cineplastic work done by Dr. Sauerbruch with his arm after the last war, and I often wonder what has happened to it. I believe that a person will wear one of those for so many years and then they give up the use of the tunnels after awhile. The muscle motors, of course, in those tunnels are very limited in the amount of movement they will produce in any transmitted wire to a hand or hook.

New elbows that are being developed are the Hosmer and Northrup elbows. All of these devices add weight to the upper extremity and pull it away from the stump. I do not think we have the ideal elbow for the above-elbow amputee.

A new pronator and supinator mechanism that you saw demonstrated in the slide of Northrup, and another one by Hosmer, are good for below-elbow amputees. That is a definite advance and I believe the "bugs" are out of those two devices. The Northrup is very much lighter in weight than the Hosmer.

Work is being done at the Army Prosthetics Research Laboratory at Walter Reed General Hospital on a positive action hook. Many of you

know the Dorrance hook, which is negative action and depends upon its gripping power on an elastic rubber band to hold the claws together. There is no control of the squeeze action of the Dorrance hook. The hook developed by the Army, on the other hand, will operate with positive control action from the opposite shoulder loop.

The miracle hand which has been described weighs 18 ounces. It is too heavy and too cumbersome, and I know very few amputees who, after they have it, want to wear it.

The cosmetic hand or glove with the Northrup pronator and supinator apparatus is a development that is going along very well. It is a synthetic rubber-like material which is stretched over an artificial hand or finger or part of a hand, and gives the appearance and color match, wrinkles and hair of a normal hand. I think it is going to be most useful in the partial amputation of the hand, that is, of the thumb and some of the fingers.

S. A. SWENSON (closing): We still need a great deal of coordination and cooperation between the surgeon, the physiotherapist and the limb fitter. After the amputee has received his prosthesis there should be some facility by which he can be instructed in its use. All of these special services for the amputee could be consolidated in civilian amputation centers distributed over the nation. There would no doubt be considerable opposition from all quarters but certainly the problem continues to grow. If such interest in the welfare of the amputee is continued, amputation centers will be established, whether under control of private interests or governmental agencies, and will provide more adequate rehabilitation of any individual who has had the misfortune to lose an extremity.

END RESULTS OF CERTAIN PROCEDURES IN THE SURGERY OF TRAUMA

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Salem, Oregon

OBSERVATIONS and accumulated experience arising from association with disability evaluation should contain something of value to the individual actively engaged in the practice of surgery, especially that surgery which concerns itself with the treatment of trauma. These observations are based upon a period of more than ten years of familiarity with disability awards as given by the Oregon State Industrial Accident Commission.

It is entirely proper that one should ask at the outset what validity conclusions so arrived at may carry and, therefore, what attention they actually warrant. There are three general considerations which should be presented in answering this. In the first place the number of cases handled by this organization is quite large, approaching some 50,000 claims per year and, hence, the number of examples of any particular condition or of any special type of treatment is greater than that seen by almost any single physician. Secondly when treatment has been concluded and the condition has reached a stationary state, these patients are seen by medical examiners who are especially familiar with the recognition and evaluation of disability; this is estimated on a numerical basis. I believe that there are two advantages in such a method. In the first place the individual who estimates the end result is not the physician who treated the patient. This eliminates the pardonable pride in his end results which might influence the evaluation of the treating physician to some extent. In the second place, although it is open to error, a numerical evaluation in terms of percentage loss of function is in general more definitely expressive than is a rating based upon good, fair or poor, this latter method or some variation is often used by physicians in reporting their end results. Lastly, I think it is a fact that a more thorough follow-up system obtains in these cases. It is often true that the original treating physician loses sight of patients who believe after a certain period of treatment or number of calls that little more is to be gained by further consultation. However, in our cases the patients hope that further treatment will result in more complete physical restoration or that as a result of aggravation disability evaluation will be revised; this tends to bring them back years after the last call to the original treating physician. As a matter of fact as long as there is any dissatisfaction with the results of treatment or whenever aggravation appears, these patients invariably "come home to roost"; and although those of us connected with this type of work often wish it otherwise, the fact remains that our follow-up is most complete. It may, therefore, be said that observations made in this field recommend themselves to the consideration of the practicing surgeon by virtue of multiplicity of example, impartial, definitive evaluation and thoroughness of follow-up.

I am, of course, aware of certain arguments which are often advanced tending to impeach the value of conclusions based upon compensation experience. The most common is that the patient fully realizes he is "before the cashier's window," and that every possible complaint or objection to his end result will be elaborated upon for the obvious reason that he believes his financial return will be based largely thereon. While this criticism is true in many instances, it is also a fact that a great number of these patients do not engage in more than the usual amount of complaining common to humanity in general. It should also be noted in this connection that examiners familiar with problems of disability evaluation are more than usually astute in discounting complaints without reasonable basis. Still another fact which obtains in patients covered by an Industrial Accident Commission which is not generally appreciated is the fact that these individuals as a rule are engaged in active physical labor and, therefore, surgical procedures performed upon them are generally subject to greater strain than the same surgical procedure would be in the patient whose occupation is largely sedentary. For example, in the case of a spinal

fusion the average private patient who is willing to suffer the consequent time loss and is able to finance the surgery and the subsequent inactivity is in general not an individual who, by reason of his occupation, is forced to put great stress upon the lower back. More often, indeed, he is a desk worker and for this reason his spinal fusion will never be subjected to the crucial tests that come with the daily lifting and carrying of heavy weights so common among industrial workers. I, therefore, submit that procedures in the surgery of trauma are given a more severe trial in the case of the industrial worker who comes under an Accident Commission than in the instance of the average private patient and it is not unfair to state that, perhaps to some degree at least, the objection connected with "the cashier's window" is met or even completely balanced by the fact that the industrial worker subjects his surgery to a more rigorous test than does the private patient.

SPINAL FUSION

It has been our observation that in certain selected cases spinal fusion is indicated and in these cases its results are generally very good. At the same time it has been evident that in a larger group of patients in whom spinal fusion was resorted to solely because all other forms of therapy were unavailing, the results were appallingly bad. In our experience the greatest benefit from spinal fusion is found in those patients below the age of forty and preferably less than thirty who have a past history of frequent back injuries resulting from minor trauma and who upon examination reveal well localized pain and tenderness and especially whose x-ray examination reveals architectural defects limited to the area of complaint. Even in these cases fusion should not be resorted to until an adequate period of conservative treatment has been tried or unless the periods of disability from minor back injuries have become sufficiently frequent to warrant more radical treatment even though the present attack might respond to conservative therapy. Our results have not been so encouraging in patients above the age of forty, even though the patient may otherwise qualify; in like manner the patient whose pain and tenderness is diffuse and not localized sharply does not appear to be nearly so good a candidate for fusion as does the individual who presents a relatively sharp localization of complaints. As to the architectural defects which lend weight to the indications for fusion, the most common are those of congenital or developmental origin. These usually consist of gross asymmetry of lumbosacral articulating processes. This asymmetry may be either in size of the respective processes or in the plane of their articulations.

The architectural defect prompting fusion should be of such nature that it can be obliterated by a fusion which includes the fewest possible vertebrae. We have noted almost uniformly that the greater the number of vertebrae fused the higher is the disability, and the more frequent are complications such as pain or pseudo-arthrosis. It is really doubtful whether the results ever warrant a fusion involving more than three vertebrae. Our experience with fusions done in the hope of alleviating symptoms resulting from an uncorrected compression fracture deformity of a vertebral-body have been most unsatisfactory and it is my observation that the operation is not justified in these cases.

The presence of any significant degree of arthritis, either osteo-arthritis or rheumatoid arthritis, has been one of the important contra-indications to fusions, even though the case may otherwise meet the requirements satisfactorily. If arthritis exists to any important degree, I am extremely doubtful that fusion will prove worth-while. We have found in these cases that disability after fusion is actually greater than that which existed before. It would seem reasonable to explain this by the generally accepted fact that arthritis involves numerous articulations and is seldom limited to only one set. Moreover, it is commonly observed that an arthritic joint tolerates any forceable increase in its range of motion very poorly; such a joint which is otherwise relatively symptomless may be quickly flared into acute activity by increased stress and strain. Thus it may well be that when certain articulations are deprived of motion by spinal fusion, the contiguous articulations are subjected to a greater range of motion and, consequently, a strain to which they are unaccustomed. Like any other arthritic joint subjected to the same stimulus, they respond by acute inflammatory reactions. The frequency with which the pain and tenderness ascends to the region of the upper end of the fusion mass in these arthritic patients seems to lend considerable support to

this assumption. I have seen cases in which, to combat the pain in its new location, another vertebra was subsequently included in the fusion with the result that the complaints promptly rose one segment higher. One wonders in these cases just how far up the spinal column the source of discomfort could be pursued if both patient and surgeon were willing to continue fusions indefinitely.

Along with the arthritic patient another type of case in which our experience shows fusion to be of no value is the patient in whom there is no indication for fusion except failure of other forms of therapy. The classic example is the individual who may or may not be within the age group mentioned who usually has no history of former back injuries or if former injuries were suffered, these have been widely separated in time and have been the result of adequate trauma. Examination reveals a very poor localization of pain which may involve most of the lumbar area or may be entirely over the sacrum or sacroiliac articulations. Tenderness, also is apparently diffused rather than localized, or if localized, fails to correspond with spinal articulations, often being over the dorsum of the sacrum or in the sacrospinalis muscle mass lateral to the lumbar articulations. X-ray examination fails to reveal any structural abnormalities or, at most, a narrowing of the intervertebral space between the fifth lumbar and first sacral vertebrae. Here one is confronted with a patient who presents none of the indications for fusion and is recommended only by the fact that all other forms of therapy have failed. The results of fusion in this type of case have been uniformly without benefit or even disastrous. When examined for closure about twelve months postoperatively, the patient will state that surgery resulted in no improvement and that if he had it to do over again knowing what he now knows, he would not submit to the operation. There is a sizeable group of these patients who will assert that they have been made decidedly worse as a result of the operation. Careful examination will disclose that a certain percentage are grossly exaggerating; however, in some instances examination will convince the impartial examiner that a considerable number are actually justified in this complaint. These patients will show greater limitation of motion, increased muscle spasm and other evidence of acute discomfort. One is convinced that they are actually considerably worse off than they were before spinal fusion, some of them being permanently and totally disabled while their disability may have been only half this extent before surgery. I am totally unable to explain what has happened in these patients. The most painstaking x-ray examination may fail to reveal any evidence of pseudoarthrosis or other defects of fusion. I am, however, convinced of the reality of these occasional unfortunate results. In any large number of patients in which fusion has been done without real indications other than persistent back pain, our follow-up demonstrates most convincingly that the majority will be unimproved while a very definite and important minority will have been made decidedly worse off as a result of the surgery.

DISC SURGERY

Our experience with partial hemilaminectomy for protruded intervertebral disc has on the whole been very satisfactory. In cases in which an actual protrusion of the disc was demonstrable and in which the symptoms and findings corresponded to what might be expected from root irritation at this point, removal of the offending protrusion has resulted uniformly in a relatively short period of convalescence and in comparatively low permanent disability. In view of the fact that the symptoms and signs which underlie the diagnosis of herniated discs are largely of a neurologic nature, we have made it a policy to restrict this operation to the neurosurgic field. An orthopedist does the fusion in instances in which this additional procedure is carried out. I believe that it is desirable to carry out contrast myelography for the purpose of demonstrating the protruded disc before surgery is decided upon. I am aware that it is not always possible thus to demonstrate the protrusion; however, these instances are relatively infrequent and the added assurance gained in those cases in which protruding discs are demonstrated is well worth the time and trouble required by the procedure. For some time the contrast medium used was lipiodol. This was removed with great difficulty and in time often proved very definitely irritating. Since the advent of pantopaque we have had no indications of any irritative phenomena and it has been uniformly possible to remove almost all the contrast medium at the completion of the

study. We do not believe that exploration without previous demonstration of the presence of a disc is indicated unless the symptoms and findings are extremely typical.

THE COMBINED OPERATION

For the past few years I have been deeply interested in the combined operation consisting of hemilaminectomy with removal of the disc herniation and at the same time spinal fusion carried out by an orthopedist. I realize that there are many who routinely advise that fusion be done in all cases in which disc surgery has been performed. My own observations do not substantiate this view. A study of our records reveals that in cases in which the combined operation has been carried out permanent disability averages 40 per cent greater than in cases in which hemilaminectomy alone has been done. The same study reveals that instances of recurrence of disc herniation have been infinitesimal.

The reasons usually given for the combined operation are first, the possibility of recurrence; secondly, the fact that an injury to a disc may be expected to change the intervertebral space and thus change the relationships of the articular facets resulting in some pain from this source.

Recurrences in our experience have been so rare as to warrant no consideration and whatever may be the virtue of the theoretic point concerning altered relationship of the articular processes, the fact still remains that permanent disability resulting from hemilaminectomy alone is increased by 40 per cent in those cases in which fusion is done. Those cases of old compression fracture of a vertebral body which, as already stated, are not benefited by spinal fusion comprise another potent objection to the theory of altered relations between articular processes resulting from disc injury constituting an indication for fusion. In these cases the compression of the vertebral body by allowing the body above to approach the body below the fracture alters the relationship between the inferior articulating processes of the vertebra above with the superior articulating processes of the fractured vertebra far more than does any nucleus pulposis herniation.

There is no reason to believe that the usual results of spinal fusion will be in any way altered by the fact that a protruded disc has been removed. In other words in all cases other than those which present indications for fusion as heretofore described there will be two groups; first, the large group of patients who have gotten no benefit from operation; and secondly, the smaller group who are definitely made worse by spinal fusion. Thus it can and does happen that an otherwise successful operation upon a disc can be completely changed into a dismal failure by the addition of an unsuccessful spinal fusion.

CASE REPORT

On July 10, 1946, J. G., a male, thirty-four years of age, suffered a severe lifting injury of his lower back. Pain forced him to stop work at once and consult his family physician who for a period of some two months carried out conservative treatment. As a result of marked right leg radiation and when no improvement was seen on conservative regimen, a herniated disc was suspected. Accordingly, the patient was referred to a neurosurgeon whose findings were sufficiently definite to convince him that right-sided disc protrusion actually existed. Since this man had to do heavy work, the neurosurgeon thought that fusion should be carried out at the time of the disc surgery and referred the patient to an orthopedist who upon x-ray examination discerned some narrowing posteriorly of the intervertebral disc between the fifth lumbar and first sacral vertebrae. It was his opinion that an unstable lumbosacral junction was present and he agreed that fusion should be done in addition to disc surgery.

The combined operation was carried out on November 5, 1946. A herniated nucleus pulposis was disclosed on the right side of the disc between L4 and L5. This was removed and followed by a fusion L4 to S1. The orthopedist provided the postoperative follow-up, and in a report dated January 19, 1948, indicated that the patient's condition was stationary and the claim ready for termination.

On February 20, 1948, the patient was examined by one of the regular examiners of the Oregon Accident Commission. The patient complained of marked pain and tenderness at the upper end of the fusion mass. There was extensive muscle spasm and abundant confirmatory evidence that complaints were well founded. Leg radiation had remained absent since the completion of surgery but back complaints were so severe that the examiner reported the patient as being, in his opinion, totally disabled. The patient was referred again to the orthopedist. After assuring himself that the present fusion was sound and no further pathological condition had developed, he suggested that another vertebra be added to the fusion in the hope of controlling the obvious pain and disability.

This additional surgery was authorized; and although the outcome is not yet evident, I fear the chances are better than not that no worth while improvement will be obtained.

I believe the great McBurney is reported to have said "God deliver me from a surgeon of but one case." Although this is admittedly an extreme case, I have, nevertheless, seen enough variance of this result to convince me that such an outcome or some degree thereof is not uncommon. While one, of course, cannot say with certainty, I believe the preponderance of evidence indicates that disc surgery alone might have been quite successful but the addition of a fusion was disastrous.

We, therefore, are forced to conclude on the present showing of our records that the additional benefit to be expected from the combined operation, is far out-weighed by the increased disability consequent upon it, to say nothing of the greatly lengthened convalescence resulting from the fusion.

While I do not believe that the combined operation should be done routinely in all disc cases, I do believe that our results clearly demonstrate that in those who present indications for spinal fusion there should be no hesitancy in carrying out the combined operation. That is to say, if the findings are of such a nature as to indicate fusion, the fact that a protruded disc exists and is removed at the same time in no way alters the need for spinal fusion.

I would, therefore, sum up our impressions by saying that, in general, operations for removal of a protruded intervertebral disc have proven quite satisfactory. It is our opinion that the removal of an intervertebral disc herniation is not, in itself, an indication for spinal fusion. We believe spinal fusion should not be done unless the indications for this operation are present and exist independent of the disc injury. I believe it is better to perform only a hemilaminectomy in those cases in which spinal fusion is not clearly indicated and, if necessary, to perform spinal fusion later rather than subjecting the whole group to the combined operation with its inevitable 40 per cent increase in permanent disability and its occasional disastrously poor outcome.

DISCUSSION

ALEXANDER P. AITKEN (Boston, Mass.): Two years ago I presented before this Society a paper on a similar subject, the end results of ruptured intervertebral disc in industry. Since the publication of that paper I have not been too popular with certain individuals in certain sections of the country. To evaluate any operation we must have a complete end result study. Dr. Smith's opinions are based upon long experience and a complete follow-up of these cases.

This past February, before the American Academy of Orthopedic Surgeons, a paper was presented on the end results of ruptured intervertebral disc by an author who reported that he had operated on 160 patients although his end results were based upon the actual analysis of ninety cases. These ninety cases were either re-examined or answered questionnaires sent to them. As a result, he came to the conclusion that 86 per cent of his cases had excellent results. Seventy patients who did not answer his questionnaire and did not return for examination were simply forgotten. It seems to me that some of these seventy patients were not entirely satisfied with their end results and that may explain why they failed to return for examination or to answer the questionnaires.

I think the opinions expressed by Dr. Smith are important in that his opinions are based upon true end result studies.

In Dr. Smith's experience the end results of the ruptured intervertebral disc were excellent. This is unquestionably true. However, in Oregon he is able to control a good deal of the surgery that is performed; he is able to see that these patients are placed in the hands of conservative and competent men.

However, no such situation exists throughout the country. In states where we have free choice we still see rather promiscuous disc and back surgery being done. The end results throughout the country of this type of surgery are still very poor.

I think in the treatment of low back injuries we have got to develop some common sense program before we can obtain universally good results. It is my belief that the ruptured disc does not occur spontaneously. I do not believe a normal disc will rupture; before any disc can rupture, I believe it must first degenerate. That degeneration takes place over a long period of time and is the end result of instability in the low back. Therefore, I believe that in the treatment of this lesion not only is it essential to remove the offending disc but it is also essential to remedy the instability in the low back.

It may seem that I am taking issue with Dr. Smith. Actually, I am doing no such thing. I agree with everything he has had to say. I believe before any patient is subjected to disc surgery he should be examined not only by a neurosurgeon but also by an orthopedist; and it should be determined before any operation is performed whether or not

that patient has an unstable type of back and whether spine fusion is indicated.

If a patient gives a long history of back pain and the x-rays show definite asymmetry in the facets, as pointed out by Dr Smith, and if that individual then develops leg pain as a result of rupture of a disc, I believe simple removal of the ruptured disc may relieve that patient's leg pain but it has done nothing for the disability caused by his unstable back.

I believe that type of back should be fused. I, therefore, am in favor of the combined operation. I believe if a patient has no abnormalities in his low back, if he is a young individual and does not have a long history of back pain, his symptoms could then be entirely due to a ruptured disc and I would agree that simple removal of the disc would effect a cure. However, if the patient has instability in the low back and has a long history of back pain, I believe the combined operation should be performed.

The end results of spine fusions as seen in industrial cases are unquestionably poor. This is due largely to poor technic. However, in our experience, if patients are carefully studied and the cause of instability determined, and if a careful fusion is performed followed by an adequate period of bed rest and immobilization, good results can be obtained. Such patients can then return to occupations of a relatively heavy nature. The poor results of fusion are usually due to poor selection of patients, poor technic and after-care.

JOHN E. RAAF (Portland, Ore.): I agree with Dr. Smith that in a majority of instances a patient who is suspected of having a protruded intervertebral disc should have a pantopaque myelogram. I am sorry I did not know Dr. Smith was planning to talk on this particular subject, otherwise I would have refreshed my memory on some of our figures. Earlier this year we reviewed our disc cases and, if I remember correctly, our pantopaque myelograms were approximately 76 per cent accurate in localizing intervertebral discs.

Our clinical impressions made before the pantopaque studies were done were about 80 per cent accurate. We believe, therefore, that if we supplement our clinical impression with information gained from the pantopaque study, we are in a better position to arrive at an accurate diagnosis than when we rely on our clinical opinion alone.

The problem of whether to limit the operation to removal of the protruded intervertebral disc or to remove the protruded intervertebral disc and then do a spinal fusion is a difficult question to answer.

Spinal fusion was done in approximately 37 per cent of our 224 patients. Perhaps that figure is too high. Dr. Smith mentioned that by fusing the disability in disc patients is increased 40 per cent. I know from our studies that the time loss was increased. I also know that the various agencies, such as the State Industrial Accident Commission who are paying the workman's compensation are out more money when a fusion is done. I believe word has been passed around among workmen that if a fusion is done the patient automatically deserves a bigger disability award than if a protruded intervertebral disc is removed and no fusion done. The fact that a fusion has been done indicates to the workman that the back is in very bad condition as a result of the injury.

In the study of our cases we found we had obtained 60 per cent excellent results, approximately 30 per cent good results and 10 per cent poor results. By excellent results I mean those patients were able to go back to their original occupations or occupations equally as arduous. Good results means that those patients were able to work but were limited in the amount of work they could do. In other words they could not carry on the heavy type of work they did originally.

WILMER C. SMITH (closing): I am aware of the fact that when disc surgery was first begun the disc alone was done without fusion, and it is true that over the years the balance of opinion has swung largely toward the combined operation. However, I wonder if this is not the result of many of those cases with architectural defects or long periods of back trouble, coming from little or no trauma, which gave a poor result upon disc surgery alone and later had to be fused.

It seems to me that the pendulum has now swung too far the other way and that ultimately it will come to rest at a point where about one-third of the disc cases will have the combined operation done and the other two-thirds will be subjected to hemilaminectomy only.

MANAGEMENT OF COMPOUND FACIAL INJURIES*

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THE story of care of a patient with a severe facial injury is a long one, both because it extends from the time of his accident until his return to gainful employment and since it is a description of close attention to surgical detail. A summary of previously emphasized material will be given.

It is to be assumed that a careful, complete physical and neurologic examination is done and an estimate of the patients general condition made. If there has been a period of unconsciousness, there has been brain damage and x-rays should be made. In very severe injuries x-rays should be taken of the cervical spine since fractures occur here following snap blows of the head. Furthermore, aside from making the patient as comfortable as possible, providing an airway, and controlling hemorrhage, no extensive facial repair should be attempted until the cerebral condition permits it.

The majority of severe facial injuries result from a missile striking the face or contact with a relatively immovable object. Cause of the trauma is mentioned since this is usually an invaluable aid in diagnosis of the type and extent of the injury. These usually result in a compound facial injury, that is, involvement of both the soft tissue and underlying bony framework, and it is impossible to separate the repair of the one from the other. The term, compound, is also used to indicate injuries which involve loss of function of eyelids, nose, seventh nerve and mouth. Possibly a better term would be "complicated" or "severe," but usage has made it applicable to extensive injuries whether fractures are of great importance or not.

The primary repair should be done as soon as the patient's general condition permits, and in the first twenty hours if possible, before swelling, organization of clots and infection have occurred. If seen after this initial period and there is the necessity of manipulation through contaminated clots and edematous tissue, it is sometimes better to just approximate the soft parts and await the subsidence of swelling before replacing the bone fragments. However, the replacement of bone fragments should rarely be delayed longer than seven to ten days because the fixation of small, comminuted chips after this time may make their accurate realignment impossible. Shock and neurologic damage may necessitate delay and an intoxicated patient should not have his jaws wired together.

In many of these patients nerve blocks, especially deep injections of the branches of the fifth nerve, are the most satisfactory for anesthesia. Occasionally field blocks or local infiltration suffice. These may or may not be combined with a basal anesthetic such as avertin. General anesthesia is to be avoided when possible but is often necessary, especially in children. When used, the endotracheal method is almost always employed although occasionally endopharyngeal insufflation is sufficient in very small children.

A complete analysis of the extent of the injury, made on the basis of examination, history and x-rays is usually done in the operating room, following which the procedure for repair is planned. Complete reliance for diagnosis cannot be placed on x-rays alone. Roentgenograms of the facial bones should be taken, however, even if they are apt to be somewhat disappointing due to the superimposition of shadows in this area. The heavier ridges of bone show quite well in the antral and verticosubmental positions, but there may be many comminutions of the maxilla, ethmoid, nasal and other thin bones that are entirely missed on the x-ray plate. For the lower jaw, complete views of both sides including both condyles should be taken because multiple fractures may be missed even at operation.

Cleaning of facial wounds is extremely important and should be done with soap and water followed by ether and saline irrigations so that local antiseptics are seldom necessary; anesthesia may have to be given before the cleaning is completed because of pain. Oil

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A B

FIG. 1. A and B, early evacuation and immediate operation; one single operation for complete repair. (Courtesy of *Ann. Surg.*, 126: 624, 1947.)

ground into the face should be scrubbed and dissolved out completely. Bits of glass from rear vision mirrors or from completely broken, shatterproof glass are especially apt to be overlooked; for this reason it is well, if possible, to find out whether or not any glass was broken at the time of the accident so that search may be made accordingly.

Débridement should be done very sparingly both of soft parts and bone. If the usual idea of wide excision of torn edges were applied, many parts of features would be needlessly sacrificed. In dealing with loose bone chips extreme conservatism should be adhered to, and it is probably better to leave in some bone fragments that might die rather than adopt the policy of removing all loose fragments and thereby possibly discard many good supporting fragments that might live.

Before suturing the soft parts, additional cleaning can be done and fresh instruments used if the mouth secretions can now be avoided. Surface key sutures may be used for the known points. These may have to be deep but should never be wide, as wide suture marks can never be completely obliterated. Buried No. 000 white silk sutures should be used between these to approximate completely all wound edges unless the skin edges are so thin that these cannot be put in. The remaining surface sutures are then placed not more than 1 or 2 mm. from the wound edges to obtain the final fine adjustment. No. 000 black silk usually suffices and may be removed in one to four days. Stay sutures may be put in from the inside of the cheek or nose. If these sutures are needed on the outside, they should always be tied over a gauze pad to prevent cutting across the wound and leaving permanent scars.

In complicated tears a correct replacement may be difficult, but a start is made at some known point such as the nostril border or the edge of an eyebrow. If none can be figured out, closure may be started in the center of the wound and the remaining areas bisected successfully until complete closure is obtained. If the final adjustment is not satisfactory, one should not be reticent about opening the wound completely and resuturing it. Triangular or trap-door flaps should be adjusted with particular care to avoid late deformity, especially about the lids, nose and mouth.

Small drains may be placed advantageously, ordinary rubber bands sufficing for small wounds. If the immediate covering of the wound is of fine mesh grease gauze, it may be removed later with minimal trauma to the wound edges and sutures. A firm pressure dressing of mechanic's waste should be applied overall to minimize hemorrhage and swelling and, thereby, infection.

Pressure dressings on the face, especially in fresh injuries, are as important as any place in the body. The use of fine, white cotton me-

chanics waste—now supplied as surgical waste—supplies an excellent medium of pressure, the final pressure, of course, being obtained with appropriate rolls of bandage. It is interesting that the first use of a pressure dressing recorded is in hieroglyphics and is in relation to facial wounds. The dressing should be regarded as a part of the operation and should be carried out with the same meticulous attention to detail.

The patient in Figure 1 represents a predominately soft tissue injury with almost no structure in the area left undamaged. By prompt surgical repair, without débridement or packing the wound open, this patient had her complete result obtained in one single operation.

Transverse facial fractures occur usually from heavy blows dispersed over the face. There may be a level of separation at the frontal zygomatic suture line and at the glabella on both sides; there may be one through the wall of the antrum that may extend all the way around and involve the pterygoid region; and frequently there is a complete separation entirely around just above the dental arch. The whole face may sag down and become noticeably elongated, and the dental arch may be completely loose to the patient's own sensation and on moving it with examining fingers.

Nasal, septal and palate fractures frequently occur along with the above separation and these small thin bones may be comminuted into multiple pieces. The nasal structure including the cartilages may be completely crumbled, and there may be one or more complete lacerations through the palate caused by the disrupted bone cutting through; the nasal passages may also be completely occluded. (Fig. 2.)

The zygomatic bone (malar or cheek bone) frequently receives the blow but is itself seldom broken. Instead, it is torn loose from its moorings at the frontal, zygomatic process of the temporal bone and the maxilla. The main displacement will be according to the direction of the force; if from the front, the zygomatic process will be crumpled back and broken by the zygoma itself; if from the side, the ascending ramus of the zygoma may be tipped in and impinge on the orbital space. In nearly all loosening of this bone the antral wall crumples; and if it should sag down too much, the orbit

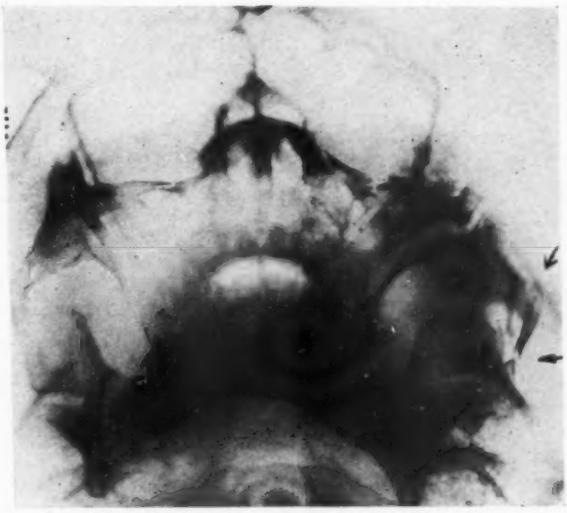


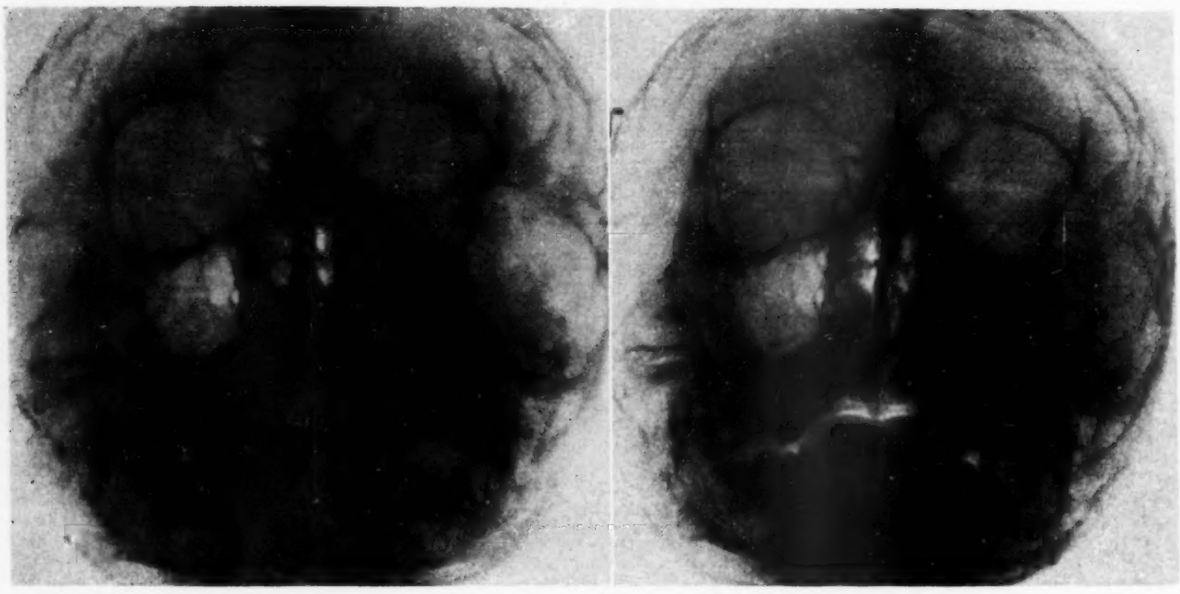
FIG. 2. Badly comminuted fractures of the facial bones separating and elongating the whole face. There is a crumbled zygomatic process on the right in addition to separation at the suture lines and depression of the orbital borders on both sides.

becomes elongated and the globe may descend so much that binocular vision is impaired. Blindness may result from section of the nerve by a loose, thin piece of bone and from intraocular or direct ocular damage. The extraocular muscles and nerves may also be torn. The lacrymal apparatus may be impinged on if the frontal process of the maxilla is driven in.

Inner canthus displacement occurs if the nose with the frontal processes of the maxilla is crushed backward, there being an actual chiseling open of the front of the face. This deformity is as important as any other in which early repair must be accomplished, because if left until fixation occurs, the canthi probably never will be sunken in normally again.

Nasal flatness goes along with the canthus displacement and the two are corrected together by withdrawing the depressed tissue and bones, molding them into their normal positions and frequently holding them there with through-and-through silver wire sutures inserted under the separated frontal processes and held on the outside of the nose over lead plates.

The general rule for repair is simply to replace these fragments and maintain them in position with the least manipulation possible. This replacement amounts to open reduction and access to the orbital border can be gained by a short incision in the buccal fornix, then into the antrum through the fracture line that



A B

FIG. 3. A, depressed orbital border; B, orbital border elevated by going into the antrum through the fracture line and raising the fragment with an elevator, then holding it in place with an iodoform pack. Density in the antral region shown in (B) was due to the iodoform pack which was removed two weeks later, leaving fragments solidly fixed in good position.

is almost always present. The depressed border can then be elevated into position with a Kelly clamp. This bone may be locked in place; but if there is much comminution, the whole number of fragments including the anterior and lateral walls of the antrum may be "mulched" in position and held with an iodoform pack in the antrum, with the end left just through the opening in the fornix. (Fig. 3.)

When teeth are available, the simplest method of immobilizing a fractured mandible is with interdental wires. These are usually of 24 or 26 gauge stainless steel which are twisted around the teeth in correct occlusion, following reduction of the fracture. To gain further stability, as in symphysis fractures, a Risdon arch can be constructed by twisting a 24 gauge wire around the molars on both sides, posterior to the fracture, carrying these wires around the dental arch, anchoring them to the individual teeth with fine wires and twisting them together in front.

However, in some fractures of the lower jaw in which interdental wiring cannot be done, a wire of the Kirschner type drilled across the fracture line may be an easy and satisfactory method of treatment.

The indication for this internal fixation may be present when the opportune early time for interdental fixation has passed and the fragments have become displaced, with compounding into the mouth, infection and local sloughing. It also may be considered in edentulous jaws, when there is much comminution and accompanying injury as in gunshot and war injuries when many teeth have been loosened or broken in displaced symphysis fractures and in fractures at the angle in which the posterior fragment is pulled out and up into the upper buccal fornix by the closing muscles. This last deformity is one of the worst to contend with and, if left uncorrected, may result in nonunion of the fragments. It may also prove to be of value in certain separations of the upper jaw.

The internal wire will insure fixation in one plane, that is, the fragments cannot slip up or down past each other. However, they might rotate in or out or they might pull apart and, therefore, the addition of an anterior wire dental arch will give a second plane of fixation that will prevent rotation and will jam fragments in impaction so that separation will not occur. If there is also a condyle fracture to deal with or if normal occlusion cannot be maintained, there can be the further addition of interdental fixation to the upper jaw.

Multiple internal wires can be used for multiple fractures or to give the second plane of fixation if desirable.

SUMMARY

In summary, an attempt has been made to correlate and re-emphasize principles of care of severe facial injuries, borrowing some material directly from previous publications.

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DISCUSSION

MICHAEL MASON (Chicago, Ill.): I cannot, of course, do more than pay humble tribute to the work presented by Dr. Brown. The contribution made by him is not confined to the field of plastic surgery or to the surgery of trauma. His real contribution has been to point out certain principles of surgery. The field in which he has chosen to demonstrate these principles has been that of plastic surgery. One would be stupid indeed not to recognize that what he told us and the brilliant results he demonstrated are basic principles and their applications. One would be even more obtuse not to realize that these same principles apply to all of surgery whether dealing with injuries or disease. Most of these principles we have learned the hard way and they have been pieced together from many sources. The plastic surgeon and the surgeon dealing with trauma can feel proud because they have contributed much toward the establishment of these principles.

They are all very simple, almost self-evident axioms, yet it is surprising how difficult it is to pound them into the heads of medical students. It is easy to give lip service but it is equally easy to disregard these principles in actual practice. They are all based on the concept of surgery as an experiment in wound healing and this means an appreciation of living tissue.

Some of these principles are: (1) Early care not just because by so doing we reduce the period of time over which contamination can occur but also because early care means early healing; (2) avoidance of secondary contamination not only because of local and general effects of infection, serious though they might be, but because we promote healing if we relieve the tissues of the need for combatting infection; (3) removal of devitilized tissues which not only helps to prevent infection but also relieves the healing tissues of the need of extruding or absorbing dead tissue; (4) restoration of normal tissue relations implies not only repair of divided or fractured structures but also restoration of the normal physiologic tissue pressure and nutritional conditions for the purpose of wound healing; and (5) avoidance of adding trauma in any fashion, mechanical or chemical, because these, too, interfere with tissue repair.

These principles apply to the extremities, abdomen and chest as well as to the face, to general surgery and all its specialties and to the large or small wound. For these reasons Dr. Brown's presentation of injuries to the face has fundamental significance for all of us.

TRUMAN GRAVES BLOCKER, JR. (Galveston, Tex.): It must be emphasized that the treatment of concomitant fractures and intracranial damage takes precedence over facial lacerations and bony displacements, but this does not mean that the latter should be neglected or hastily done in an amateurish or haphazard manner. It is extremely important that careful planning be carried out on those individuals who have tissue loss, keeping in mind that the individual is to be restored, first, functionally and, secondly, cosmetically; and this to be accomplished with as few operative procedures as is possible to get the final result.

During the war Dr. Brown, by appointment from the Surgeon General's office, organized and gathered around him sufficient young men trained in plastic surgery to treat and rehabilitate approximately 15,000 wounded soldiers in the various plastic centers in this country. As a consultant he was able to standardize more or less the methods for their most efficient care. Dr. Brown has made one of the greatest contributions to American Surgery. He devised and popularized thick split grafts; and now that everyone can cut one, they have been added to the armamentarium of every surgeon who is treating trauma.

DONALD M. GLOVER (Cleveland, Ohio): The conservation of tissue which Dr. Brown called attention to is most essential. Here as nowhere else in the body, except perhaps in the hand, the principles of débridement must be altered to fit the needs of the future appearance of the patient.

I would like to emphasize just two points that Dr. Brown brought out, one being the question of the type of shelving facial laceration, or what he called the trapdoor laceration, which we see so commonly in accident rooms everywhere, and which are attractively laid out so that they fit

together nicely and are usually sutured as they lie and almost always result in unpleasant hypertrophied scars. These wounds should always be excised to provide perpendicular margins which will permit perfect approximation.

One other point he made I should like to emphasize also; that is the terrific deformity resulting from fractures of the maxilla involving the orbita floor. The triangular fragment that is so commonly displaced downward and rotated, if immediately replaced, gives an excellent result; whereas the results of delay are dropping of the eyeball, imperfect function and disfigurement which require many operations for correction.

ELECTRIC BURNS OF THE HEAD AND ARM WITH RESIDUAL DAMAGE TO EYES AND BRAIN

JOHN PAUL NORTH, M.D.
McKinney, Texas

ELECTRIC trauma occurs frequently enough to merit consideration by the general surgeon. The case reported herein illustrates most of the more common complications of the passage of an electric current through the body. Many factors influence the severity of electrical effects upon the tissues. Even though voltage may be known, the actual quantity of current (amperage) cannot be calculated in a given case because of the wide range of the resistance offered by different body tissues under varying conditions. For example the resistance of dry skin is considered to be 5,000 ohms but this may be reduced to 300 ohms by the use of moist saline electrodes as employed in legal electrocutions. The destructive effect of a current is directly proportional to the electrical resistance of the traversed tissue. The current tends to seek paths of least resistance and passes most readily through blood or cerebrospinal fluid. In so doing, however, the walls of such channels offering greater resistance to the current are subject to correspondingly more severe damage. In consequence thromboses of arterial vessels with necrosis of tissues or hemorrhage from the rupture of damaged vascular walls are seen as late sequelae. Similarly meningeal or cortical brain damage may follow the passage of a current through the cerebrospinal fluid. A flat bone, such as the skull, presents a large surface of high resistance. Intense heat is generated which may, as in the case of our patient devitalize large areas.

Survival of the patient is determined more by the path which the current takes through the body than by its intensity. The points of entrance and exit are significant and receive the most intense effect. Contact with ground at the moment of the accident is also an important element. There is general agreement that a current passing through the chest is most likely to be lethal because of its effects upon the heart. On the contrary, passage of a current into one foot and out the other has never been reported to be lethal. In our patient the course of the current from scalp to left hand, thus by-passing the thorax, was a fortuitous circumstance. Excellent discussions of electropathology are contained in the articles by Pearl[8] and Jaffe.[5]

Electric burns have certain characteristic features. The tissues are heated momentarily to the fantastic level of an electric arc which may be 5500°F. to 7000°F. There is complete coagulation of tissues within a circumscribed zone but the systemic effects of extensive burns from sources of lesser intensity are absent. The barriers to bacterial invasion are sealed and infection is not likely to be a serious consideration. It has been proposed that limited areas of a burn might be excised and skin grafted immediately. However, as pointed out by Edwards and Bowie[4] and as illustrated in this case, the extent of the damaged blood supply cannot be estimated immediately and it is preferable to treat conservatively until the slough is well demarcated. The case reported by Smith and Rank[9] of the survival of an Australian soldier whose burns required amputation of an arm and two legs indicates that recovery may follow even very extensive electric burns. The method of plastic repair utilized in this patient is one of several which might be employed. We were faced with a situation in which a very scanty blood supply was available from the margins of the surface defect and none at all from its bed of devitalized skull bone. The full thickness of scalp which was shifted backward carried a bilateral vascular supply through the temporal arteries. This flap of scalp remained viable even though its lower edge was detached from its anchorage to the skin of the neck.

Traumatic cataracts are a recognized sequel of electric injuries. Adam and Klein[1] have compiled fifty such cases from the literature. They have usually been observed in patients who received electric burns of the head although occasionally the flash which occurs at the moment of contact may be responsible alone without any actual surface burn. Arc welders

and workers at blast furnaces also develop cataracts. These cataracts have been noted to appear from three weeks to two years after injury. The involvement is first observed in and usually remains confined to the anterior capsule. Choroiditis is often an early complication as in our case, but the cataract is not considered to be secondary to this nor is it due to albuminous coagulation. It is generally believed that the electric discharge destroys the capsular epithelium with consequent accumulation of fluid between it and the lens fibers. These cataracts may require as long as three years to reach maturity. An awareness of their occurrence and of early and continued ophthalmologic observation is obviously important. Some cases require operation, particularly if the involvement is bilateral.

Damage to the central nervous system by the passage of an electric current has been studied extensively in both experimental animals and electrocuted humans. There are immediate thermal effects and late degenerative sequelae. The case discussed herein illustrates initial trauma to the occipitoparietal cortex, brain stem and cerebellum with partial recovery. Alexander[2] and others have described patients who developed localized muscular atrophies months after injury. These are considered as manifestations of focal areas of encephalomalacia resulting from vascular damage and its consequent anoxia. In general both types of lesion appear in proximity either to vascular channels or to pools of cerebrospinal fluid. This is to be expected since blood and cerebrospinal fluid are excellent conductors of electricity and the walls of the channels through which these fluids circulate generate an intense heat proportionately to their greater resistance. The microscopic alterations in brain tissue vary considerably. Langworthy[7] has described focalized destruction of cells especially in the medulla, cerebellum and the cerebral cortex and also perivascular areas of hemorrhage. Following lethal exposures there may be quite startling disruptions not only of individual cells but of entire tissue planes as if the brain had been subjected to an internal explosion.

There is one characteristic electrocution injury which deserves passing comment. Burrows[3] and others have reported a number of cases of fracture or fracture-dislocation of the upper end of the humerus by violent muscular contraction without direct trauma. In most instances these accidents have resulted from the short circuit of an ordinary house current when some appliance such as an electrical vibrator or a washing machine was used. Not infrequently the victim is momentarily rendered unconscious; if not, he finds himself unable to loosen his grasp upon the electrical appliance. The fractures produced are extensively comminuted and may be bilateral. Another type of fracture in which delicate lines of cleavage are visible to the naked eye but not apparent roentgenologically has been described by Jellinek[6] in cases of lethal electrocution.

CASE REPORT

N. I., aged twenty-two years, was on the roof of a house which was being moved, fending off overhanging electric wires with a stick held in his right hand. It appears that he was grasping a metallic strip along the ridge of the roof with his left hand. The day was clear and dry (no rainfall for at least a week with a low relative humidity of 30 to 40). A wire, carrying a single phase direct current of 7,200 volts, made contact with the metal strip along the ridge of the building. The patient later recalled a blinding flash and believed that as he recoiled the back of his head touched a second high tension wire. Dr. P. L. Allen of Weatherford, Texas, saw the patient on February 10, 1947, within ten minutes of the accident. There had been no respiratory arrest and artificial respiration was not required. The current had produced a severe burn at the point of entrance on the scalp and complete dessication of the left arm almost to the shoulder. The left arm was disarticulated at the shoulder on the day after injury. He was stuporous and blind until the fifth day when he regained consciousness and could perceive gross objects.

He was transferred to the Veterans Administration Hospital on the fifth day after injury with a deep burn of the scalp and back of the neck. It was sharply delimited and measured about 13 by 26 cm. He was confused and showed marked dysmetria, adiadochocinesia, hyperactive tendon reflexes and a sustained clonus of both ankles. His vision was greatly diminished; he had acute conjunctivitis and iridocyclitis and the optic discs were indistinct.

The scalp sloughed rapidly, denuding an area measuring 13 by 20 cm. and including the entire occipital and about half of the parietal bone. It was obvious that unless this exposed bone could be covered quickly an extensive section of cranium directly over the cerebellum and brain stem would be lost. The patient was in good general condition and, contrary to earlier predictions, seemed to

have an excellent chance for survival. There was no suitable base for a free skin graft. Therefore, despite the necrotic condition of the tissues on the back of the neck, it was determined to attempt to cover the exposed cranium by detaching the scalp along the hairline at the brow and sliding it backward over the defect. The blood supply of this flap of scalp would come entirely from the temporal arteries since there were no available vascular sources on the back of the head. On February 28th an incision was carried from in front of one ear across the vertex at the hairline to a corresponding point in front of the other ear. The scalp was freed from the pericranium to which it was firmly congealed, slipped backward and anchored somewhat precariously to the damaged tissues at the back of the neck. The denuded area was covered anteriorly by split thickness skin grafts taken from the front of the thigh. An error was committed in not immobilizing the head after this operation. In consequence of this and the poor vitality of the cervical tissues the suture line gave way and the scalp retracted somewhat, leaving a portion of the occipital bone and a crescentic area on the back of the neck exposed again. We had been successful, however, in providing cover for more than half of the previously exposed skull. The bone which now lay uncovered in the wound measured 9 cc. transversely by 5.5 cc. vertically. It showed no indication of viability and it was conceded that it would eventually sequestrate. On March 28th an attempt was made to obtain vascularization from the underlying dura by making burr holes through both tables of the bone. There was no bleeding from these drill holes and for months thereafter their appearance remained unchanged with no evidence of granulation tissue. At about this time the posterior aspect of the neck was successfully covered with split thickness grafts.

Throughout this period and during ensuing weeks the patient had mild fluctuations of temperature with peaks never exceeding 100°F. His hemoglobin was maintained within a range of from 13 to 16 Gm. by a series of blood transfusions. He was ambulatory and at times left the hospital on leave. Penicillin and sulfadiazine were given intermittently in preparation for and following operative procedures. On three occasions (in April, September and October) he complained of severe headache, photophobia, dizziness and on one occasion showed nuchal rigidity; but he always had a sterile cerebrospinal fluid.

After taking counsel with several plastic surgical consultants an attempt was made to swing a pedicled flap from the interscapular area to the occipital defect. This required transfer of skin over a considerable vertical distance with no intermediate site to obtain good secondary vascularization. The attempt, made in several stages during

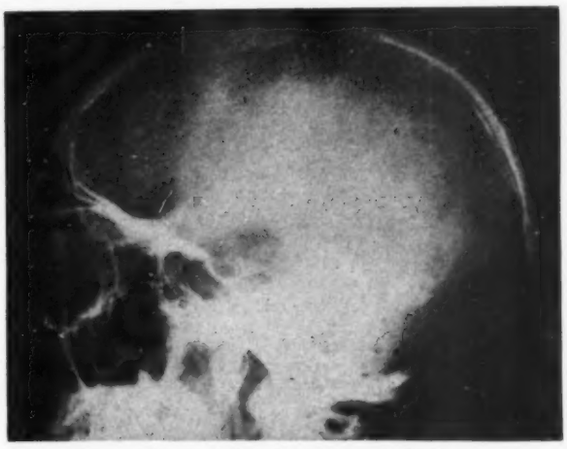

FIG. 1. Lateral x-ray showing the occipital sequestrum and still larger cranial defect which extends forward in the midline to the foramen magnum. After removal of the sequestrum the exposed meninges were covered by sliding the scalp backward from the browline.

May and June, resulted in loss of the entire flap, leaving the situation as before. It was then decided to revert to the scalp transfer method which previously had been partially successful. This was planned with the idea of removing the portions of skull which might sequestrate later. There were several postponements due to episodes of upper respiratory infection and of meningismus during which sequestrum formation occurred in a portion of the skull. Therefore, on October 15, 1947, a sequestrum extending from the occipital protuberance forward to the foramen magnum was gently removed with rongeurs. It was observed that the coagulating effect of the burn had penetrated the skull and that the dural sinuses in the vicinity of the torcula were thrombosed. Once again the scalp was freed at its anterior border and shifted backward about 5 cc. to cover the freshly exposed meninges. (Fig. 1.) A split thickness graft was placed anteriorly upon the denuded pericranium and this time a massive head and body cast of plaster was applied to immobilize the head in extension for ten days. This procedure was successful and the patient, completely healed, was discharged on December 12, 1947. (Fig. 2.)

The nuchal muscles which attach to the bast of the skull had been replaced by cicatrix. Although the patient appeared to have strong extensor power, it was feared that a sudden jar or violent flexion of the head might produce an occipito-atlantal dislocation. Therefore, prior to discharge he was provided with a light plastic collar which would maintain the head in mild extension and at the same time afford protection over the occipital skull defect. As was anticipated, the patient has not worn this brace since discharge and at the present time he is driving a farm tractor. It was considered inadvisable to plate the skull defect

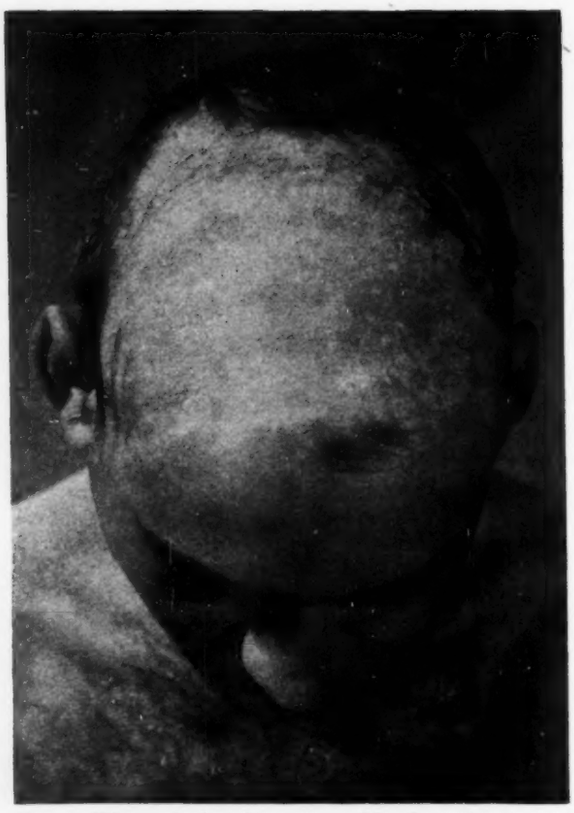

FIG. 2. The scalp has been moved backward twice to cover the occipital defect and the pericranium resurfaced with split thickness skin grafts taken from the thigh.

inasmuch as the rim of such a plate would constitute a margin of the foramen magnum. In this location, unless absolute permanent fixation of the plate could be secured, fatal medullary compression might occur with any displacement of the plate.

Reference has been made to the impairment of vision and the acute inflammation of the eyes evident at the time of the patient's admission. During the early months after injury there were recurrent attacks of iritis and the gradual development of lenticular opacities and optic neuritis was noted. After ten months there were definite cataracts in both eyes, the opacity in the right eye being more extensive. Fundi at this time showed a pallor of the discs with pigmentary deposits in the perimacular zones. Two months later the cataracts were static but the pigmentary changes in the retina were still progressing. When last seen in May, 1948, (fifteen months after injury) the patient's vision was 20/70 in both eyes but could be corrected to 20/30 in the right and to 20/40 in the left eye. The anterior portion of the eye was normal. Lenticular opacities mainly involved the anterior subcapsular area bilaterally and slightly involved the posterior portion of the capsule in the right eye. Although present in both, optic atrophy was more pronounced in the left eye. In that eye there was complete disorganization of the macula, pigment absorption and peripapillar atrophy. The visual fields were constricted and showed a central scotoma bilaterally and on the left a temporal heminopsia. These visual defects were regarded by Dr. Maxwell Thomas, ophthalmologic consultant, as due to a peripheral macular rather than a central lesion.

Immediately after injury this patient showed signs of severe injury to the central nervous system, particularly involving the cerebellum and brain stem. After ten months he complained of mild frontal headaches after exertion. Cerebellar incoordination had improved but he had a tendency to fall to the right in walking and there was nystagmus on right lateral gaze. All tendon reflexes were hyperactive and there was sustained bilateral ankle clonus. The indications at this time were of severe damage to the occipital lobe, moderate upper motor neuron disturbance and mild injury to the cerebellum and parietal cortex. It was noted by Dr. Carroll Kern, neurosurgical consultant, that the patient's residuals were amazingly small considering the amount of bone and soft tissue destruction and the observation that the torcula and both transverse sinuses were thrombosed on the dura beneath the occipital bone.

When observed fifteen months after his injury, the patient was slightly ataxic but this was scarcely noticeable in his gait. He walked on a slightly wide base but was able to do 3 miles without fatigue. His sensation and hearing were entirely normal. Manifestations of cerebellar disturbance were greatly improved and only a minimal nystagmus remained on looking far to the right. Tendon reflexes were increased bilaterally. There was an unsustained patellar clonus and a gross sustained ankle clonus bilaterally. The Babinski reflex was strongly positive but confirmatory Chaddoch's and Gordon's signs were negative, placing the motor tract damage mainly in the brain stem. Despite the improvement with the passage of time, some of these residuals are expected to be permanent although only slightly incapacitating.

SUMMARY

In the case reported a man received a severe electric burn of the head and arm from contact with a wire carrying an electric current of 7,200 volts. Although his left arm had to be amputated at the shoulder, he survived the injury. The burn on the back of his head was grafted by detaching a double pedicled flap of scalp at the hairline of the brow and sliding it backward to be attached to the skin of the neck. Virtually the entire occipital bone sequestrated and was removed. He developed bilateral cataracts and optic atrophy. The brain underlying the burned area was injured,

leaving him with obvious, but diminishing residuals of occipital lobe, cerebellar and parietal cortex damage.

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DISCUSSION

Ralph Carothers (Cincinnati, Ohio): I would like to emphasize one point Dr. North made. Men come in with electrical burns and all you see is a little black spot on an arm or leg which does not look much different from a cigarette burn on a white tablecloth. The house man or intern will want to excise it and close it either with a little graft or bring the edges together. The point is that I cannot tell and I do not believe anybody else can tell how extensive that slough will be. It may go from a ¼ to 6 inches across before it is finished. Furthermore, if a patient has one of these burns on an arm or leg, it is a wise precaution to apply a tourniquet loosely to the limb above because you may need it in an awful hurry.

James Barrett Brown (St. Louis, Mo.): Dr. North's demonstration of how to take care of a patient deserves great commendation. He did not give up in the face of great difficulty and the man is alive and well.

There are some technical points that might be of interest. If a flap is over over dead bone, that bone, of course, will not revive and it will have to be taken out later. As Dr. North said, he knew this bone would have to be removed.

We have made mistakes thinking perhaps we could get a flap to work over dead bone, relying on later sequestration from under the flap; but over the face the flap is too apt to wrinkle up and possibly not be sufficient, so that in working around the face, it is probably best not to put flaps over dead bone. Dr. North recognized the fact that the bone was going to come out, and on this flat surface this plan has probably saved a good deal of time for the patient.

Another thing of importance in work around the scalp and skull is that when flaps are raised it is highly important not to get the periosteum off the bone; because if it is raised or lost, a wound will be left that will not heal for a long time; when it does heal, it will be discolored and glazy with thin epithelium; and if it is on the forehead, it will be very unsightly. In taking up the flaps in his patient, Dr. North realized the importance of the intact periosteum and had an adequate base to pick up a free skin graft.

Another interesting point is a comparison of civilian and military lesions. There is not much difference except that civilian lesions sometime seem worse than military lesions. The main differences we could make out were that military lesions are apt to be quite dirty and in time of war multiple wounds from shell fragments occur that practically are not seen in civil life. Both Dr. Blocker, with his tremendous experience in the Texas blast, and Dr. Mason, with all the work he has done on damaged hands in his clinic will possibly agree.

In the war thousands of burns occurred and many of them were electrical burns. They usually did not occur from enemy action but from the usual mistakes and carelessness that accounts for civil accidents. About 83 per cent of the burns we saw in the war were due to someone's carelessness and not to enemy action. These lesions occur in civil life just the way they do in the housekeeping of troops, and the anatomy, physiology and pathology are the same in either situation.

This completely charred arm that Dr. North had to deal with, of course, had to be taken off. He spoke of the damage to blood vessels, and Doctor Carothers warned of the sudden, severe and sometimes fatal hemorrhage thatl can occur from the arteries higher up in the extremities. Repeated hemorrhage frequently occurs in these extremities.

I would like to say something about amputation for thermal burns (not electrical burns). In a plastic surgery center the philosophy of treatment should be the opposite of amputation. Here an effort should be made to build up parts and amputations done only at the last moment. At no time during our Army work in plastic surgery were any amputations done for burns that I know of; occasionally we removed a finger or so but no major amputations were done.

There was evidence that the Germans did not believe as we did. We heard of some instances of Germans having both hands cut off because of burns, and we had one American soldier who had had this treatment in a German hospital. This radical procedure practically should never be done. It would be much better just to wait; and even if only one digit were left, it should be saved instead of taking off the whole hand or arm.

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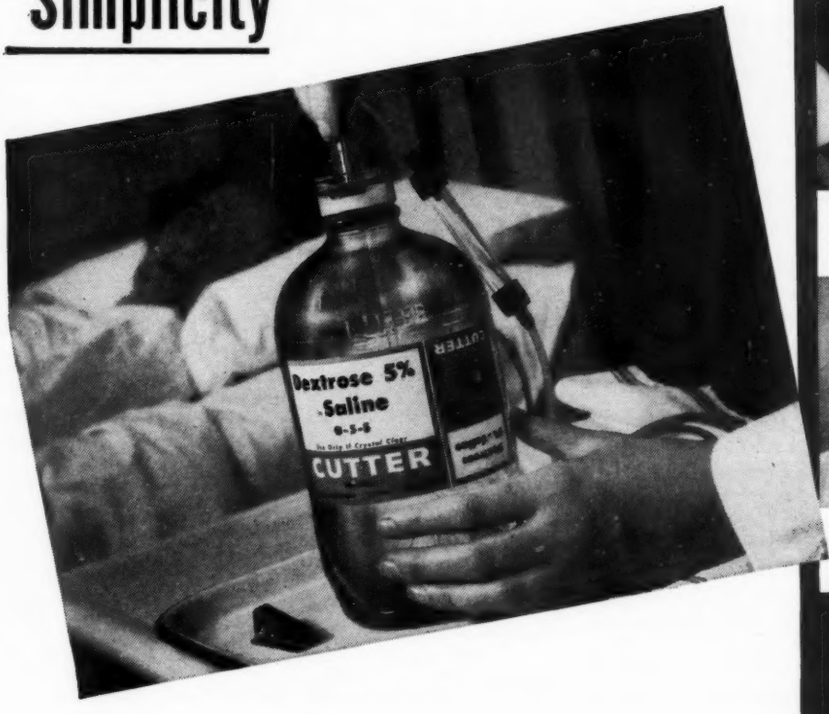
Simplicity



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Outside the Ivory Tower

(*continued from page 24*)

SOOCHOW is a walled city 2,500 years old and famous for its scholars and beautiful women. The population is said to be one-half million. The faster trains make the fifty-three miles to Shanghai in one and one-half to two hours. A bus line runs north to Changshu and another south to Nanking but any other analogy to an American bus is a figment of the imagination. Unless he has had long experience in New York subways let the rider beware!

There are motor roads inside the city now, but until you have driven a 2½ ton truck through the streets crowded with rickshas, wheelbarrows, bicycles, waddling babies, blind beggars and pedicabs (a hybrid vehicle representing a cross between a bicycle and a ricksha large enough for two people to ride while a man out in front pedals), you have not yet experienced all the doubtful thrills of driving. Tien Sz Tsaung (Heavenly Market Place), site of Soochow Hospital, Soochow University, Laura Haygood Girls' School and St. John's Church, appears as a haven of quiet after one has driven a truck from Shanghai over terrible roads and through this crowded city. Incidentally, we have just received a 2½ ton truck through the American Advisory Committee. We put up a mat shed garage for 3½ million dollars Chinese currency (U. S. $30) to house it and built a driveway of some broken brick hauled off the Southern Presbyterian Mission compound, thus providing them with garden space.

Today would furnish a cold reception to the traveler, with the thermometer at 20, the humidity high and only a few scattered stoves in the hospital but none in the wards. What does the well dressed doctor wear? Three sweaters, a woolen shirt, a field jacket and a long gown lined with raw silk keep one barely able to function in this extreme weather.

This afternoon two of us made a survey of our former heating system. The boiler was carried off by the Japanese but most of the radiators were left. Pipes, valves and steam traps will all have to be replaced before we can have steam heat again. Then will come the problem of fuel. Even the electric light plant cannot get enough coal (even at C.N.C. $4,500,000 per ton) to run constantly, and fuel oil is as scarce as water in the Sahara.

(From a letter from Soochow Hospital, Soochow, Kiangsu, China.)

GRADUATES of Class A medical schools desiring rotating internships under U. S. Navy auspices may be commissioned as Lieutenant (junior grade) (MC), U.S.N.R., with the full pay and allowances of that rank. Graduates commissioned on this basis may accept a civilian internship in any hospital in the United States, provided the hospital internships are approved by the Council on Medical Education and Hospitals of the American Medical Association. A medical officer so commissioned shall remain on active duty in the Navy for a period of one year following completion of internship. He will be given every encouragement to transfer to the U. S. Navy provided his services, professional, physical and moral qualifications have been satisfactory. Near the termination of his obligated service (one year) and agreement to transfer to the regular navy he will be considered for residency training on a competitive basis with other officer personnel of the Regular Navy Medical Corps.

THE U. S. Civil Service Commission has announced an examination for filling medical officer (rotating intern and psychiatric resident) positions in St. Elizabeths Hospital, Washington, D. C. Medical officers (rotating intern) are paid $2,200 for the first year and $2,400 for the second year. Medical officers (psychiatric resident) are paid from $2,400 to $4,100 a year, depending upon the amount of approved postgraduate training the applicant has completed. Appointments are open for July 1, 1949. Internships consist of two years of rotating service, and psychiatric residencies consist of one to three years in psychiatry. To qualify for internships applicants must be third or fourth year students in an approved medical school; however, they may not enter on duty until they have successfully completed the full course of study. Applicants for psychiatric residencies must be graduates of an ap-

(*continued on page 36*)

In Nutrition Rehabilitation... A Good Start

Any sound nutrition rehabilitation program starts with an adequate breakfast. Important as is an adequate breakfast in normalcy, doubly so is its importance in convalescence when reconstruction of body tissues and functioning hinges largely on nutrition. During recovery periods from disease, it is virtually mandatory that the dietary burden of the day be equally distributed over the three meals, hence breakfast becomes especially an important meal. Overtaxing the patient's digestive capacity is thereby avoided; an even flow of essential nutrients is made available for supporting the metabolic processes of rehabilitation.

As a means of assuring breakfast adequacy, a widely endorsed basic breakfast pattern is used. Consisting of fruit, cereal, milk, bread and butter, it forms a sound foundation upon which to plan the morning meal. Other suitable foods can be added if required by the situation at hand.

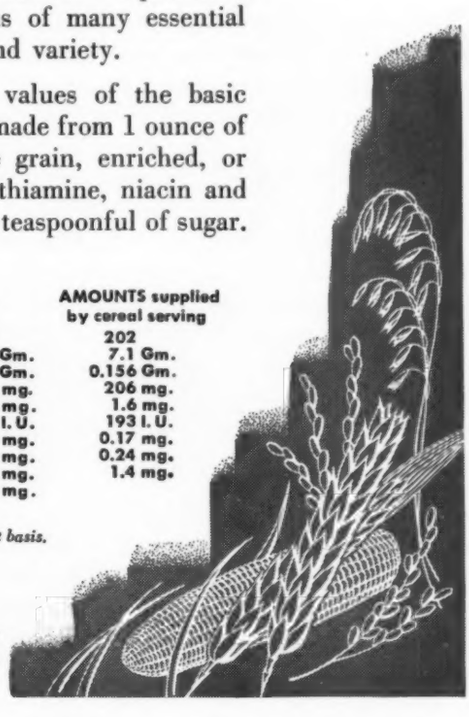
Because of its many nutritional and dietetic values, the cereal serving—hot or ready-to-eat breakfast cereal, milk, and sugar—is extensively recommended as the principal dish of this basic breakfast pattern. This cereal serving, rarely contraindicated and widely applicable, lends itself especially for use in rehabilitation dietaries. It provides, along with significant contributions of many essential nutrients, appetizing tastefulness and variety.

The table depicts the nutrient values of the basic breakfast and of the cereal serving made from 1 ounce of ready-to-eat or hot cereal* (whole grain, enriched, or restored to whole grain values of thiamine, niacin and iron), 4 fluid ounces of milk, and 1 teaspoonful of sugar.

The presence of this seal indicates that all nutritional statements in this advertisement have been found acceptable by the Council on Foods and Nutrition of the American Medical Association.

BASIC BREAKFAST	TOTALS supplied by Basic Breakfast	AMOUNTS supplied by cereal serving
Orange juice, 4 fl. oz.;		
Ready-to-eat or Hot Cereal, 1 oz.;	CALORIES..... 611	202
Whole Milk, 4 fl. oz.;	PROTEIN..... 20.7 Gm.	7.1 Gm.
Sugar, 1 teaspoon;	CALCIUM.....0.465 Gm.	0.156 Gm.
Toast (enriched, white), 2 slices;	PHOSPHORUS .... 488 mg.	206 mg.
Butter, 5 Gm. (about 1 teaspoon);	IRON ..... 3 mg.	1.6 mg.
Whole Milk, 8 fl. oz	VITAMIN A..... 1074 I. U.	193 I. U.
	THIAMINE..... 0.52 mg.	0.17 mg.
	RIBOFLAVIN..... 0.87 mg.	0.24 mg.
	NIACIN..... 2.3 mg.	1.4 mg.
	ASCORBIC ACID .. 64.8 mg.	

**Composite average of all breakfast cereals on dry weight basis.*



CEREAL INSTITUTE, INC.

A research and educational endeavor devoted to the betterment of national nutrition.

135 South La Salle Street • Chicago 3

Outside the Ivory Tower

(*continued from page 34*)

proved medical school, with the degree of doctor of medicine and, in addition, they must have completed an approved internship or must now be serving such an internship. No written test is required for the medical officer positions. Details about the requirements are given in the examination announcement. Interested persons may secure information and application forms from the U. S. Civil Service Commission, Washington 25, D. C., from most first- and second-class post offices and from Civil Service regional offices. Applications will be accepted until further notice in the Commission's Washington office.

DR. Fuller Albright associate professor of medicine at the Harvard Medical School, has been given the Squibb Award for 1948 of the Association for the Study of Internal Secretions, it has been announced by Dr. Warren O. Nelson, of the College of Medicine of the State University of Iowa and Chairman of the Association's Committee on Awards. The Squibb Award is given each year by the Association for distinguished research contributing to the advancement of knowledge in the field of endocrinology. This is the eighth year in which the Squibb Award has been made.

THE first of a series of scientific motion picture films on various phases of endocrinology was recently released by Schering Corporation of Bloomfield, N. J. The subject of the Schering film is, "The Physiology of Normal Menstruation." Completely animated in color and available with or without sound the film presents the currently held theories concerning the phenomenon of menstruation. The film was produced by Schering for medical schools and various medical societies. It may be obtained free of charge for showing before interested groups by writing to the Medical Service Department, Schering Corporation, Bloomfield, N. J.

MALARIA, which attacks one hundred million persons a year, has been described as one of the chief contributing causes of the world food shortage since it strikes at the heart of the world's agricultural areas in the tropics and subtropics.

THE College of Physicians and Surgeons of Columbia University has received a bequest amounting to approximately $140,000 for use in medical research, it was announced by Dean Willard C. Rappleye. The fund, which was received from the estate of the late C. Evaretta Romaine, will be used to investigate diseases of the blood system and other medical problems.

AN AUTOMATIC COLOR CAMERA manufactured by the Coreco Research Corporation, New York, is the first practical answer to the photographic and pictorial problems of medical science and research.

The CORECO, Model 300, the only completely automatic color camera, establishes a standard of photography in which all photographic factors are constant at all times. The sharp, accurate, true color pictures of any specified body surface or cavity are easily obtained through special automatic focusing brackets and push button operation, thus furnishing perfect pictorial evidence for medical, dental, surgical and allied study.

Already used by doctors, hospitals, universities, institutions, research foundations and agencies of the United States, Canadian and British Governments, the CORECO Automatic Color Camera is extremely beneficial for purposes of diagnosis, documentation of case histories, lectures and the preparation of medical papers.

This camera, the result of more than eight years of medical and technical study by the Coreco Research Corporation, is designed to eliminate the need for any photographic knowledge or experience on the part of the operator and provides ease and speed of operation.

Approximating a Speed Graphic in size and weight, the CORECO Camera is hand-held, requiring no tripod. A special Color Corrected Bulb within the camera assures correct light and precludes the necessity of light stands, reflectors and flash bulbs. Packaged in one complete unit with case and able to be operated from any AC or DC connection, it can be carried as easily as a portable typewriter and made instantly available in any clinic, hospital, doctor's office or patient's home.

Priced to fit the purse of the private physician as well as the medical institution and with operating costs limited to the price of standard color film and processing, the CORECO Automatic Color Camera is the first to bring practical, visual documentation to medical research and general practice.

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- Equally effective in many ocular infections—conjunctivitis, meibomitis, blepharoconjunctivitis, keratitis, dacryocystitis, corneal ulcer, marginal ulcer, when due to Bacitracin-sensitive organisms.

Bacitracin is supplied in 20 cc. rubber-stoppered vials containing 2,000 and 10,000 units, and in 50 cc. rubber-stoppered vials of 50,000 units; Bacitracin Ophthalmic Ointment-C. S. C. is available in ⅛ ounce tubes; Bacitracin Ointment-C. S. C. (for cutaneous application), in ½ ounce tubes. Both ointments provide 500 units of Bacitracin per gram. Literature available to physicians on request.

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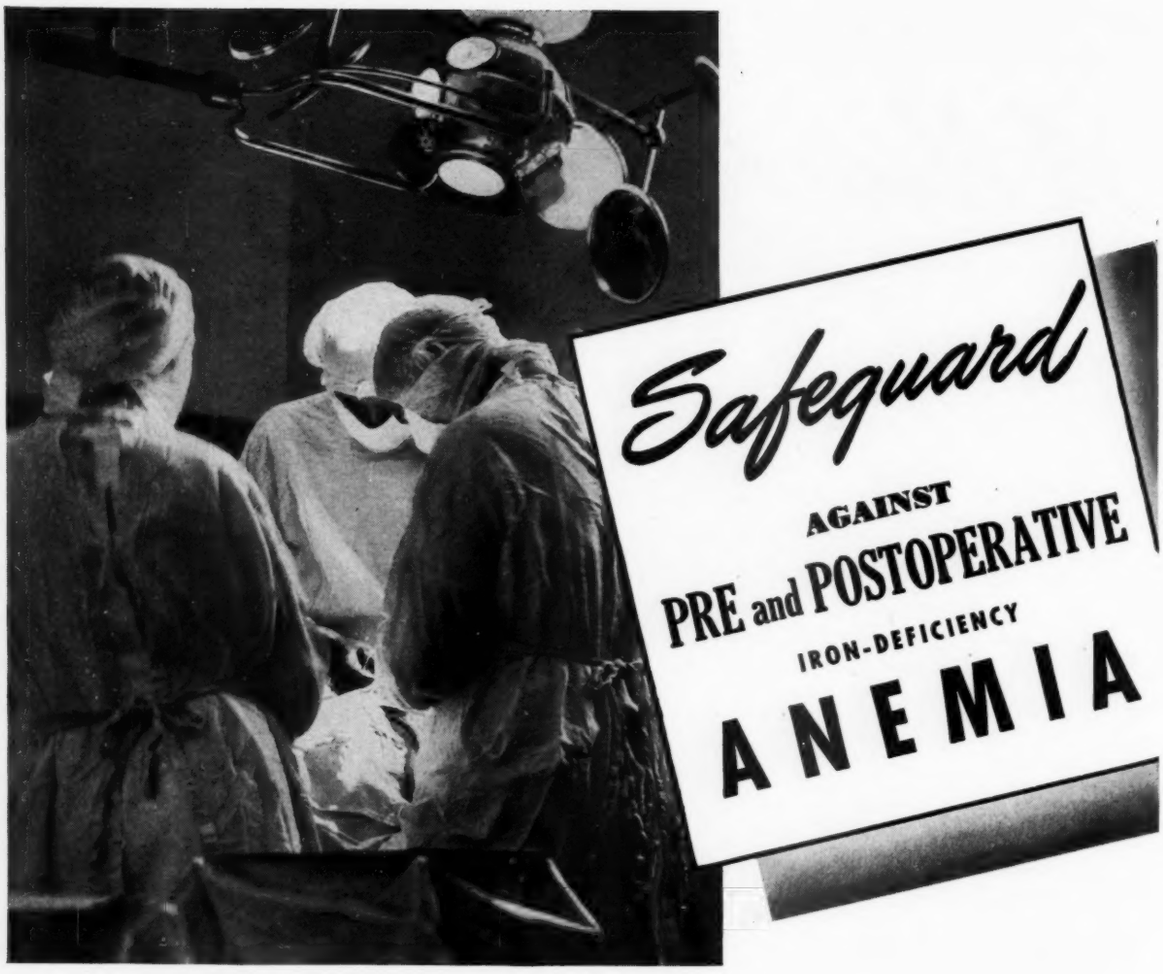

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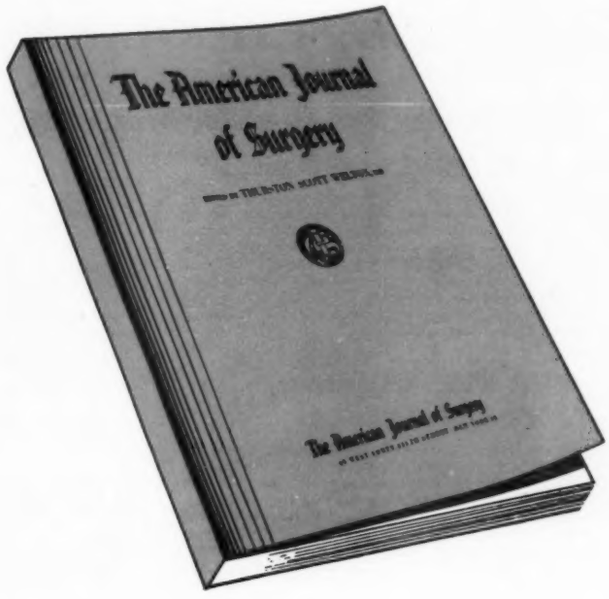

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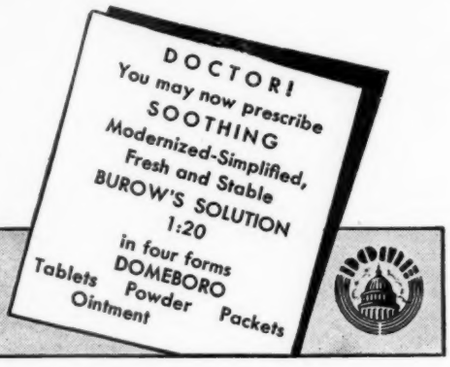

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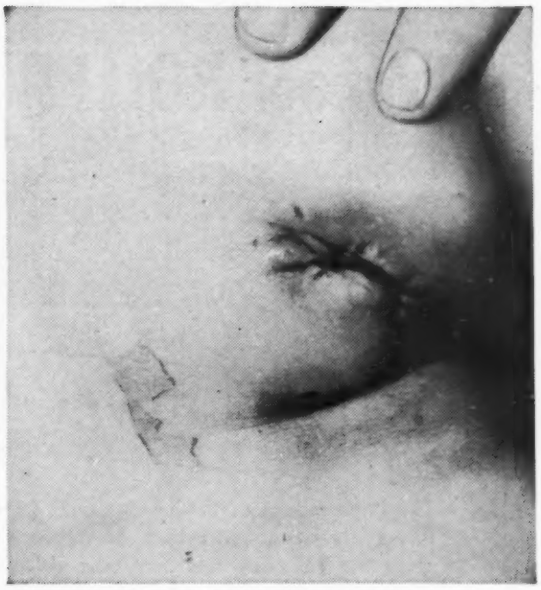

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Boehme, E. J.	The Treatment of Chronic Leg Ulcers	The Lahey Clinic Bulletin, 4:242 (1946)
Bowers, Warner F.	Chlorophyll in Wound Healing and Suppurative Disease	Amer. J. Surgery, LXXIII: 37 (1947)
Cady, Jos. B. and Morgan, W. S.	Treatment of Chronic Ulcers with Chlorophyll	Amer. J. Surgery, LXXV: 4 (1948)
Johnson, Harold M.	Dermatologic evaluation ...	Arch. Dermat. & Syph. 57:348 (1948)
Langley, W. D. and Morgan, W. S.	Chlorophyll in the Treatment of Dermatoses	Penn. Med. Journal, Vol. 51; No. 1 (1947)
Rafsky, Henry A. and Kreiger, Charles I.	Treatment of Intestinal Diseases with sols. of w. s. Chlorophyll	Rev. Gastroent Vol. 15:549 (1948)

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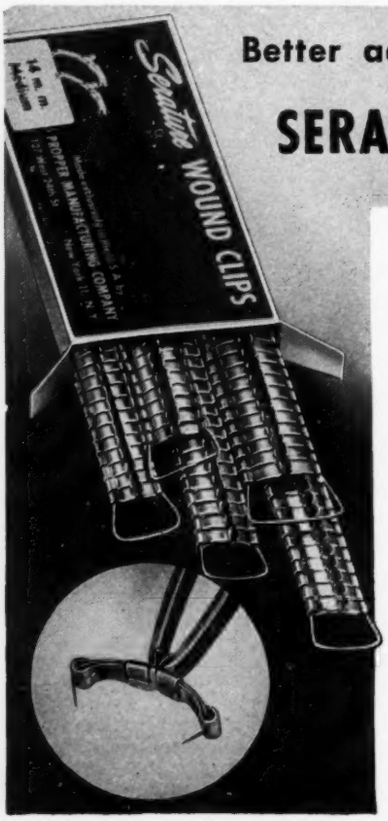

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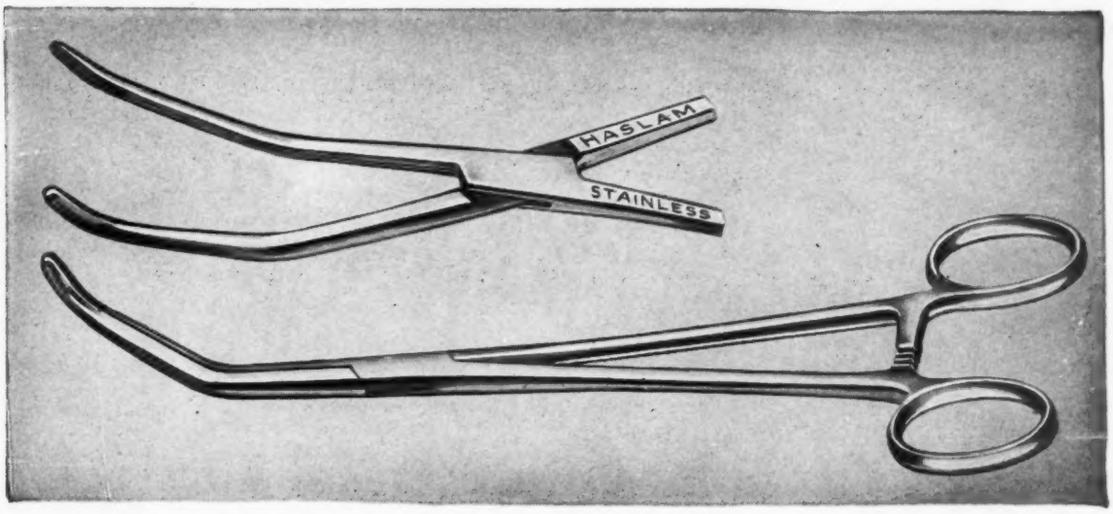

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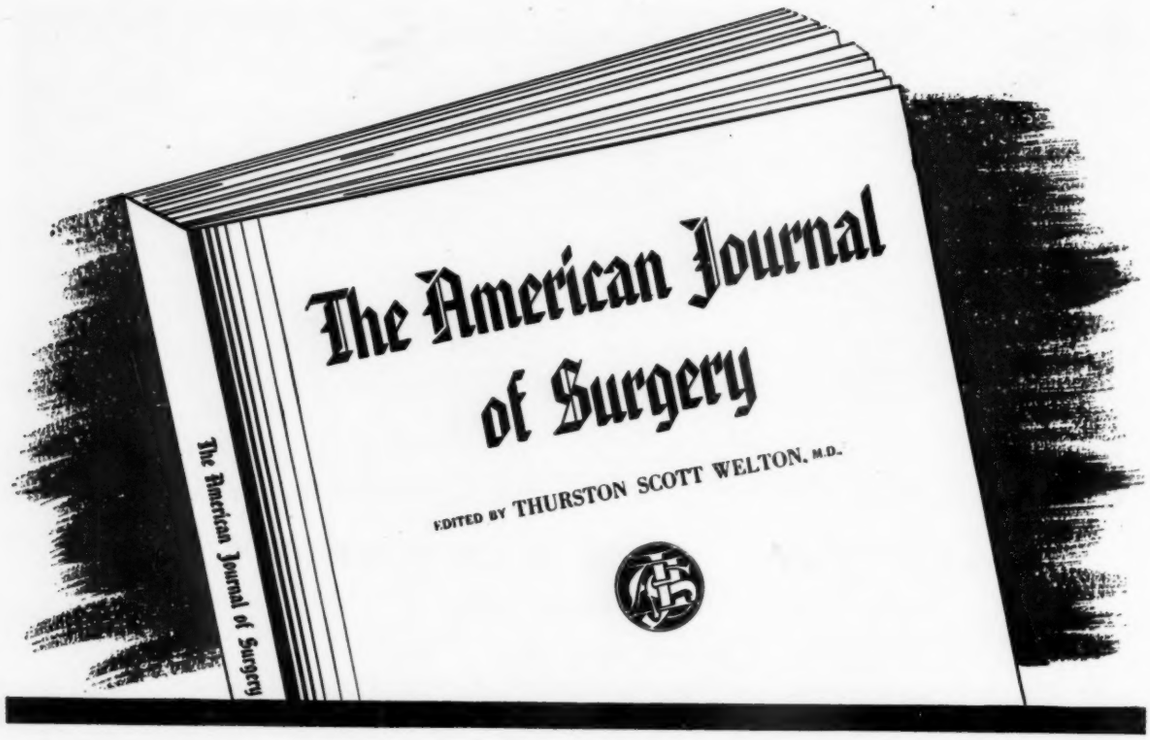

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The American Journal of Surgery

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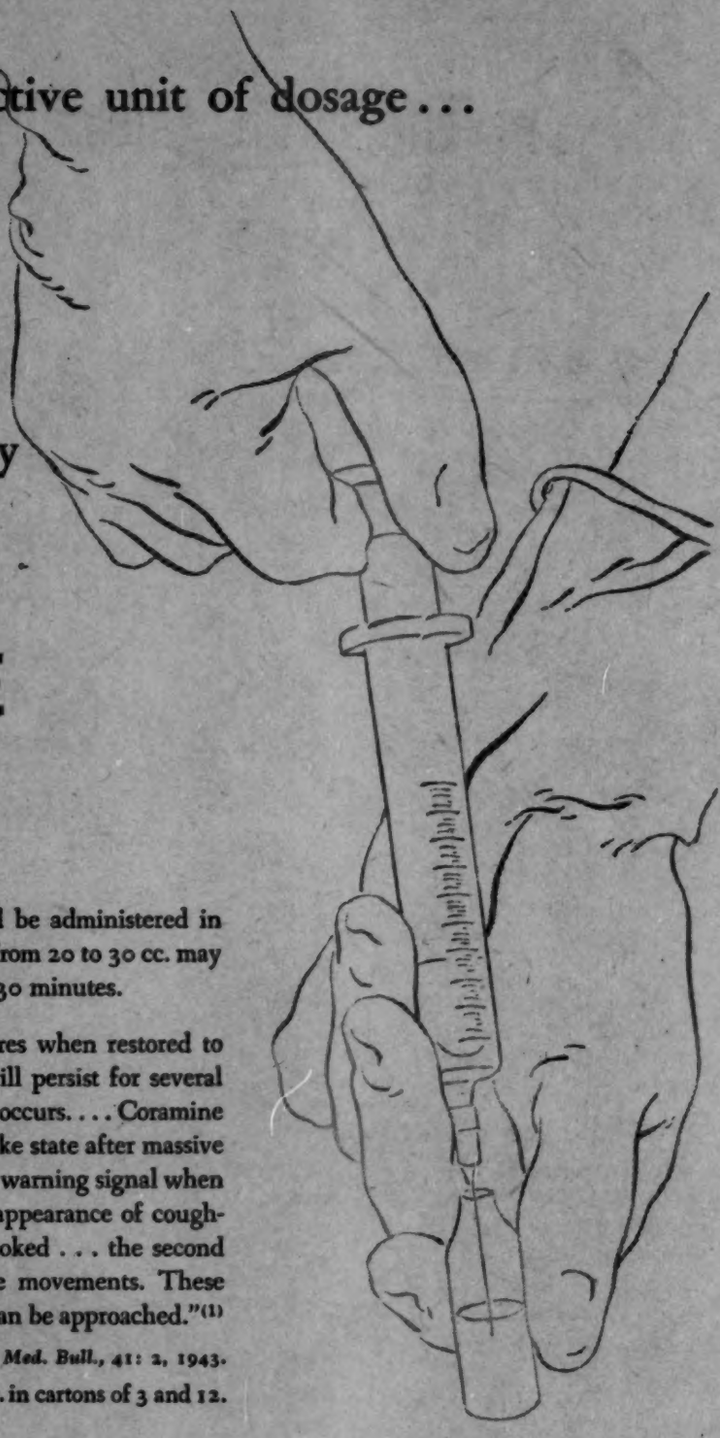
the most effective unit of dosage...

in respiratory
and circulatory
emergencies



CORAMINE

5 CC. AMPULS

At least 5 cc. of Coramine should be administered in emergencies. Repeat as necessary. From 20 to 30 cc. may be given safely within a period of 30 minutes.

"Intramuscular and venous pressures when restored to normal by the use of Coramine will persist for several hours before a gradual decline again occurs.... Coramine is a safe agent to use in the shock-like state after massive hemorrhage.... The drug carries a warning signal when the injection should cease by the appearance of coughing. If the coughing sign is overlooked ... the second warning signal is mild convulsive movements. These appear long before the lethal dose can be approached."(1)

1. GUNTHER, L.: *U. S. Naval Med. Bull.*, 41: 2, 1943.

CORAMINE AMPULS of 5 cc. in cartons of 3 and 12.

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